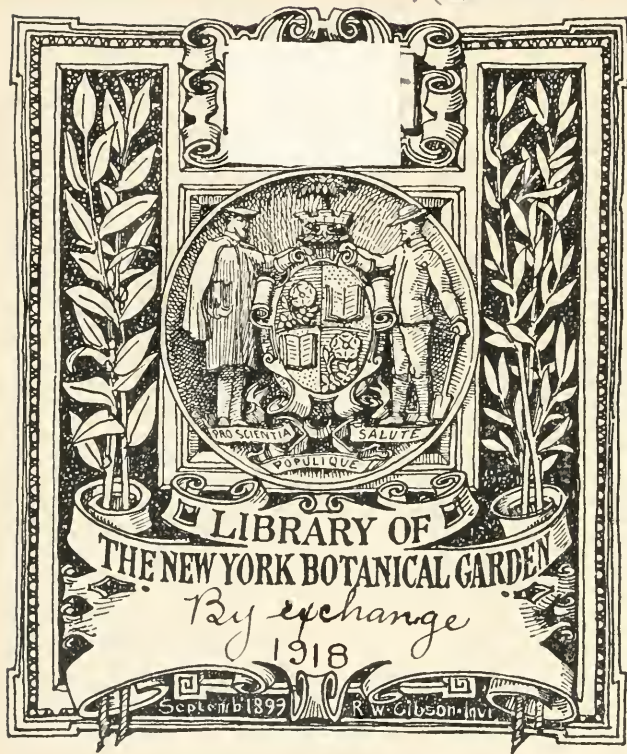


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UNITED STATES DEPARTMENT OF AGRICULTURE
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OFFICE OF THE SECRETARY

Contribution from the Office of Farm Management
W. J. SPILLMAN, Chief

Washington, D. C.



May 9, 1918

PASTURE LAND ON FARMS IN THE
UNITED STATES

By

E. A. GOLDENWEISER, Statistician, and
J. S. BALL, Assistant in Farm Accounting

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SOURCE OF DATA.

The figures on pasture land on farms in the United States presented in this bulletin were obtained from a tabulation of the agricultural schedules collected by the Bureau of the Census in 1910. Owing to the fact that the census period is limited to three years, the Bureau of the Census was unable to tabulate this item. When, however, the necessity of increasing food production in the United States made it particularly important to ascertain the amount and location of agricultural land not at present utilized for raising crops the Bureau of the Census granted permission to the Office of Farm Management to undertake the tabulation of pasture land. Although the schedules were collected seven years ago, it was thought that no great changes in distribution of pasture land had occurred since 1910 and that in any case these data were of great value as the first enumeration ever tabulated of the amount and distribution of pasture land on farms in the United States. (See note on page 11.)

The census inquiry on which this tabulation is based is as follows:

PASTURE LAND: Acres in this farm used exclusively for pasture in 1909:

	Acres.
Woodland pasture, covered with pasture grasses, but containing more or less scattered timber.....	
Improved land in pasture, but which can be plowed or mowed.	
All other pasture land.....	

The tables in this bulletin show the returns for each of the three types of pasture for the United States as a whole, for geographic divisions, for States, for counties, and for the Territory of Hawaii. No data on pasture were collected for Alaska or Porto Rico.

ARRANGEMENT OF MATERIAL.

Tables I and II present, respectively, the acreage of farm pasture land by geographic divisions and States, and by counties. For comparative purposes certain other items are included in these tables. The total land in farms is taken from the census reports. The land in crops also is taken from the census reports but includes estimates for the acreage of fruit crops, which are not reported in the census. These estimates were obtained by dividing the number of trees given in the census by the average number of trees per acre as estimated by the Bureau of Plant Industry. The figures for the item "All other farm land" are obtained by subtracting those for the crop and pasture land from those for the total farm land. This item includes woods not pastured, yards and barnyards, roads, fallow and waste land. (See note 2, page 12.)

Table I also shows the percentage distribution of farm land into its various classes, and Table II, the percentages for crop land and pasture land by counties. A column showing the number of acres in pasture per 100 acres in crops also is included in Tables I and II.

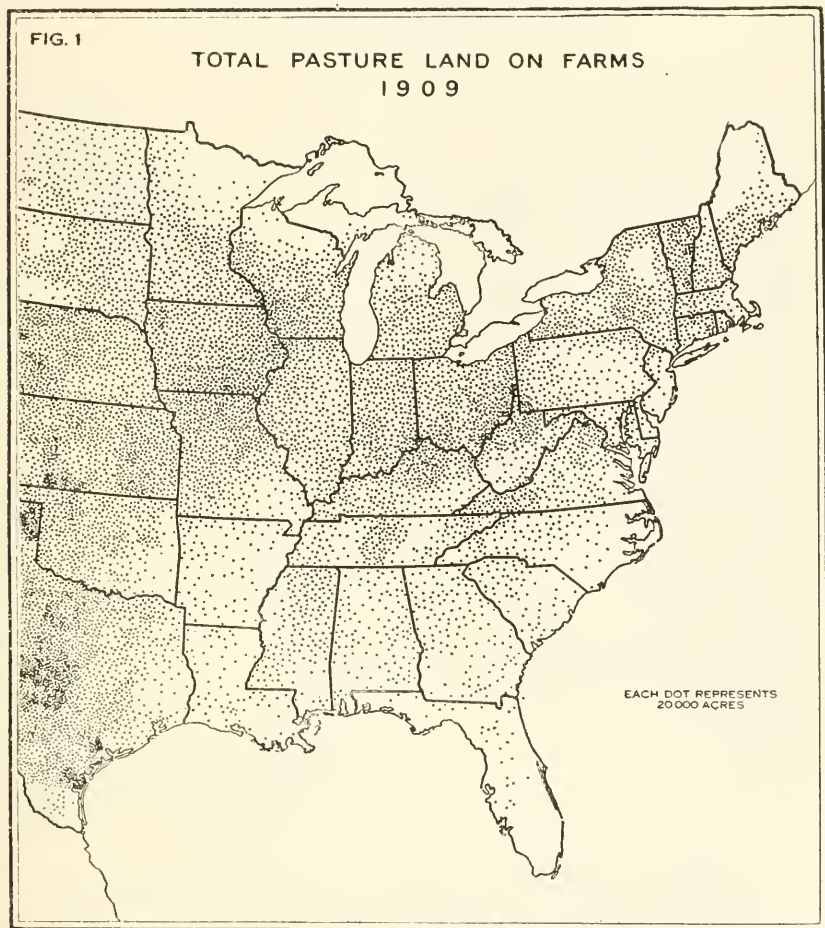
FARM PASTURE LAND IN THE UNITED STATES AS A WHOLE.

Of the total farm land, which comprised about 879,000,000 acres in 1909, somewhat more than one-third was in crops, about one-third was in pasture, and somewhat less than one-third comprised all other kinds of farm land. The fact that there was nine-tenths as much pasture land as crop land is enormously significant in connection with the possibilities of expanding crop production. It must be noted, however, that a large part of the pasture land is unimproved, about 99,000,000 acres being in "woodland pasture" and 108,000,000 acres "other unimproved pasture"; but even the improved pasture alone represented over 84,000,000 acres, or nearly one-tenth of the total land in farms. This improved pasture doubtless consists largely of land that is pastured in rotation with crop production in intermediate years. It may be used for crops three years out of four, two years out of three, or one year out of two, but most of it undoubtedly is arable land; in fact the definition of this type of pasture is "improved land in pasture but which can be plowed or mowed." Of the unused farm land, that is, land not in crops or pasture, which comprised about 269,000,000 acres, or 30.6 per cent of the total land

in farms, about one-third, 10.4 per cent, was in woodlots, and two-thirds, 20.2 per cent, comprised fallow land, waste land, land in farmstead, roads, etc.

GEOGRAPHIC DISTRIBUTION OF FARM PASTURE.

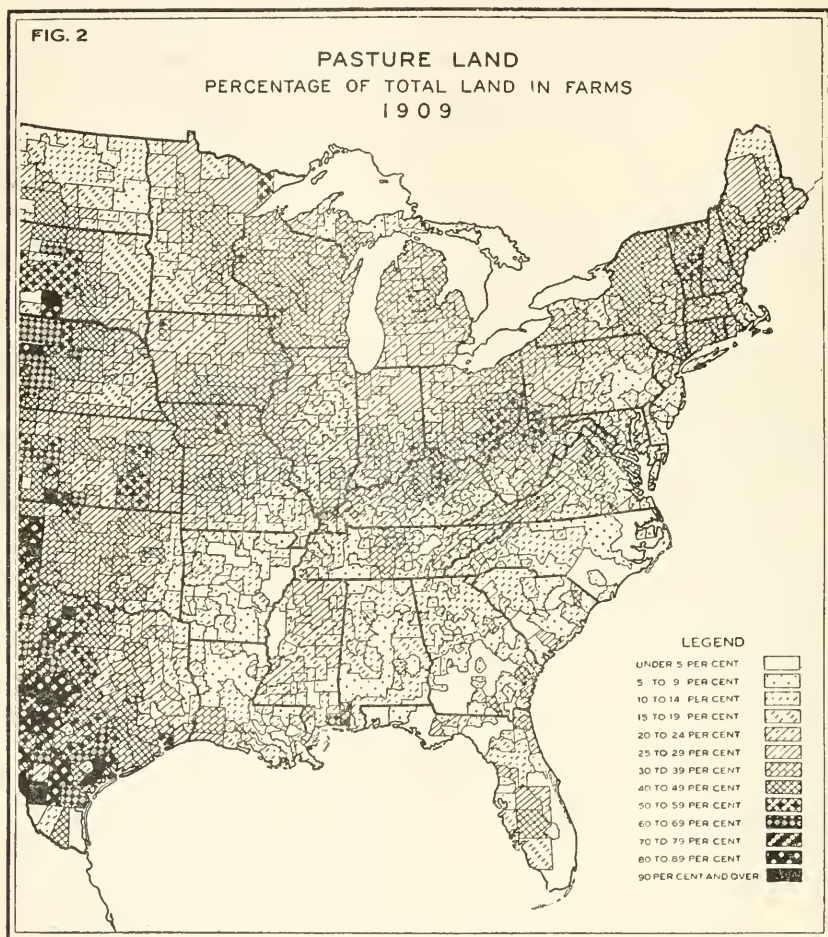
Figure 1 shows the geographic distribution of the total pasture land on farms, each dot representing 20,000 acres. The map includes only the portion of the United States east of longitude 99° W., since



climatic conditions, the extent to which the public land has actually or nominally been transformed into farms, and other factors are so diverse in the Western States that comparison of the statistics of pasture land in the East with those for the West is impossible. It will be seen that the greatest concentration of farm pasture is in Texas, Kansas, Nebraska, Missouri, and Iowa. Pasture is also impor-

tant in the Lake States, the Ohio Valley, New York, and New England. The Southern States have comparatively little pasture.

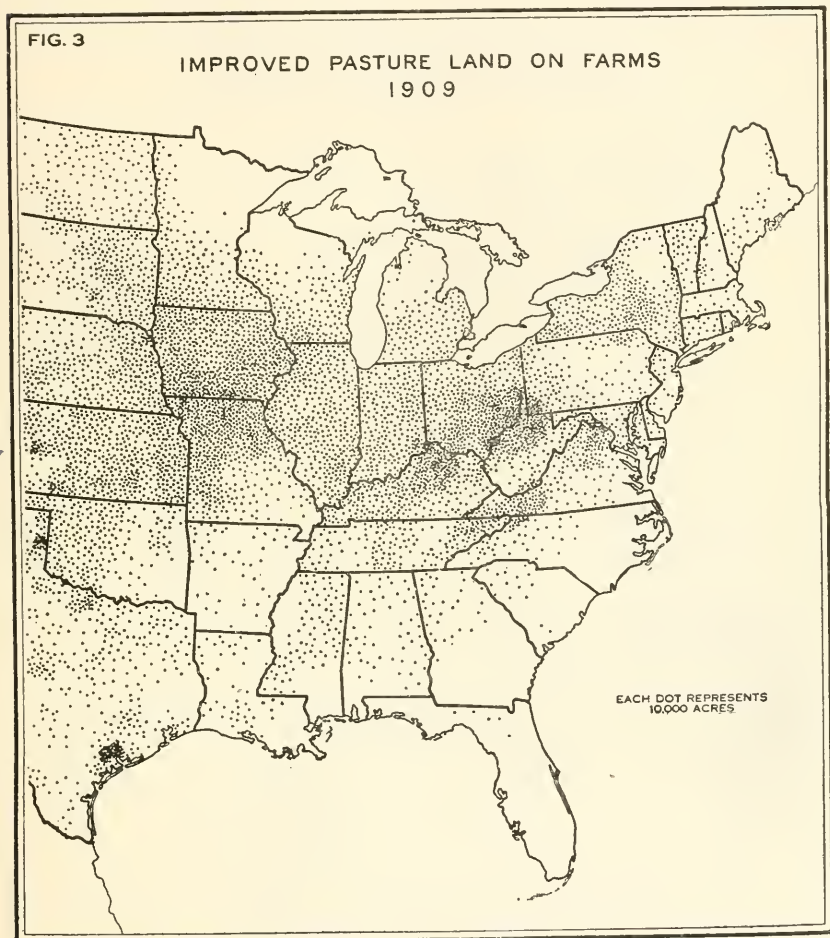
Figure 2 shows the relative importance of pasture as compared with total farm land. Only six counties east of the 99th meridian have 90 per cent of the farm land in pasture and only a small number of counties have over 50 per cent. In much of the area



where corn and winter wheat are grown, pasture comprises from one-fifth to one-half of the total farm land. In many of these areas pasture occupies a regular place in a three-year or four-year system of rotation.

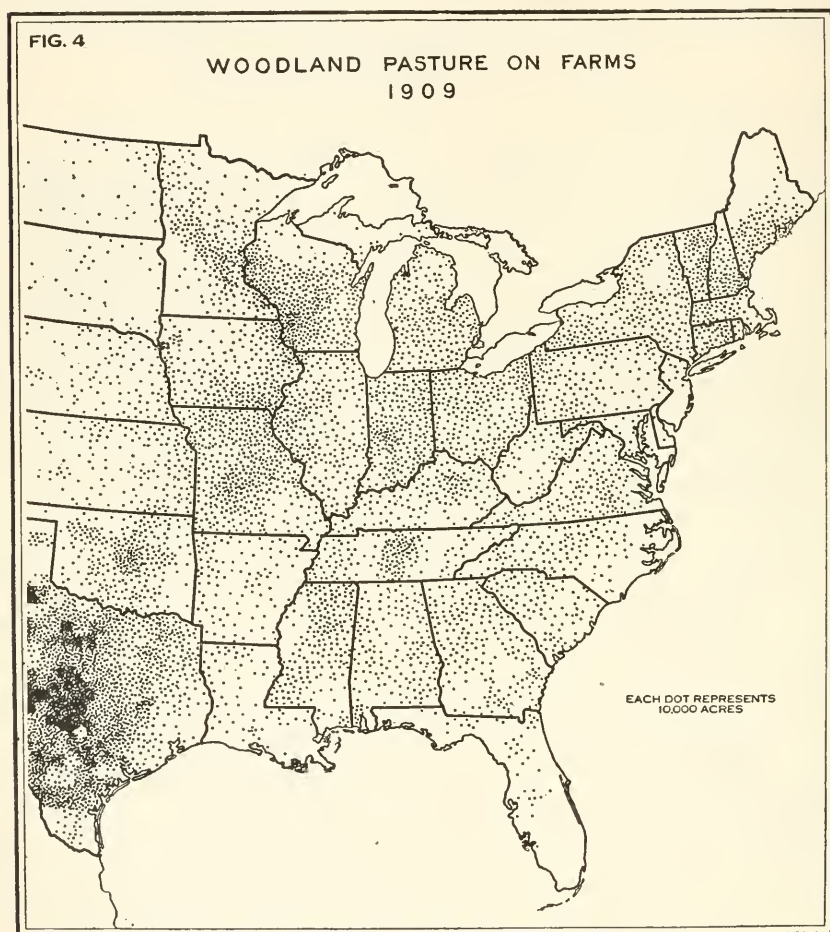
Figure 3 shows that it is in the great agricultural States that improved pasture is mostly concentrated. The most important areas are in eastern Ohio and northern West Virginia, Kentucky, Iowa,

and northern Missouri. Improved pasture is unimportant in the Cotton States. The dense area shown in southern Texas is probably due to defective classification. Woodland pasture (shown in figure 4) is, on the other hand, markedly concentrated in Texas, and is distributed fairly evenly throughout the eastern half of the country. This Texas woodland pasture is, in the main, brush-land, largely



mesquite. In the Southern States there are vast tracts of forest land; nevertheless woodland pasture is not as dense as in the Northern States, and in part of the South it is practically nonexistent. This is due partly to the lack of species of grass well adapted to pasture, and partly to economic conditions which make unprofitable any utilization of poor pastures. There is a noticeable belt of woodland pasture in Minnesota and western Wisconsin, owing in part, to the rolling or hilly topography.

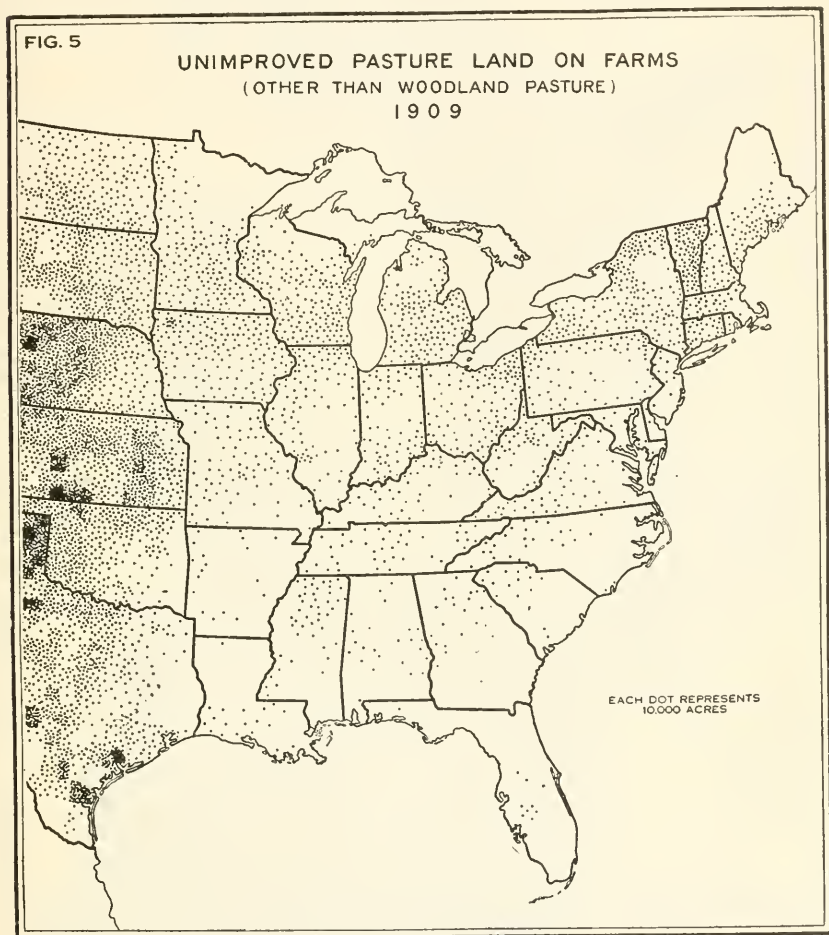
Unimproved pasture other than woodland pasture (fig. 5) is distributed more densely through the Great Plains region largely because much improved range land is included in the pasture figures. In the East unimproved pasture is distributed somewhat more densely through the Northern than through the Southern States and is most dense in Vermont and parts of northern New York.



The pasture reported as unimproved by the enumerators in the East is largely land that is too rough for cultivation, and in the West is largely grazing land where the rainfall is too low for the production of staple crops.

Figure 6 shows the distribution of farm land that is in neither crops nor pasture. As explained above, this type of farm land comprises woodland, waste, and fallow land, as well as yards, barnyards,

roads, etc.; in short, all farm land that is not utilized directly for agricultural production. In New England, in the South Atlantic and East South Central States, as well as in Arkansas and Louisiana, a large proportion of this land is in forests and marshes. On the other hand, in parts of North Dakota, South Dakota, Nebraska, and Kansas, as well as in the Western States, an appreciable pro-

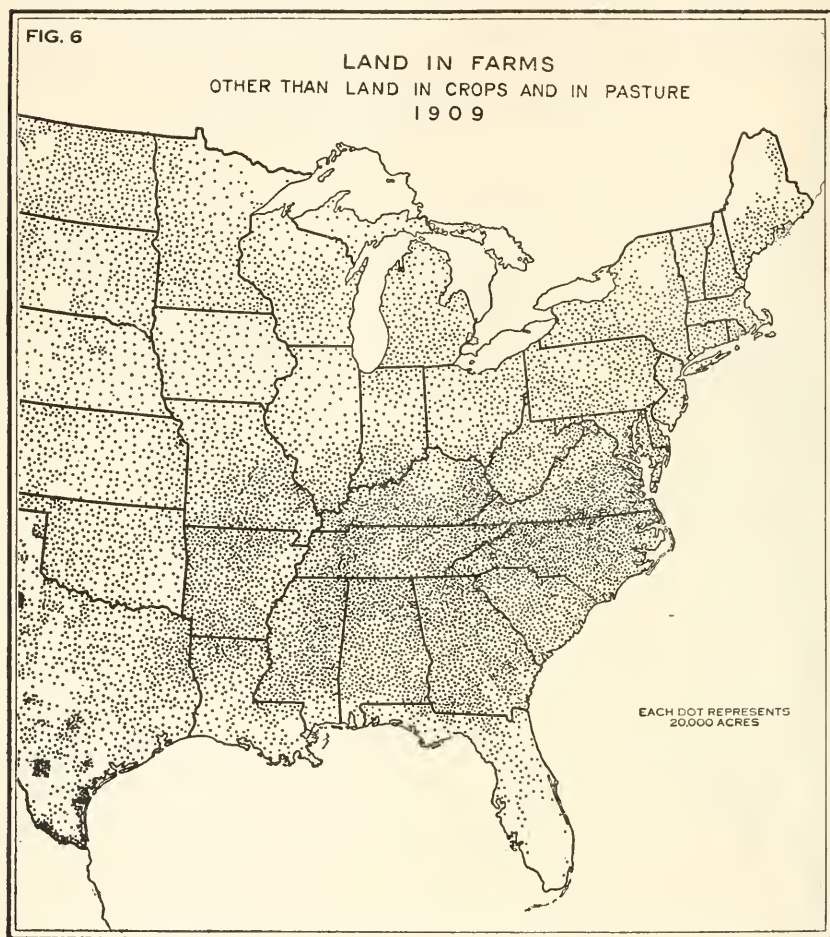


portion of the cultivated area remains idle every year because of the practice of summer fallowing. It therefore can not be considered as waste land.

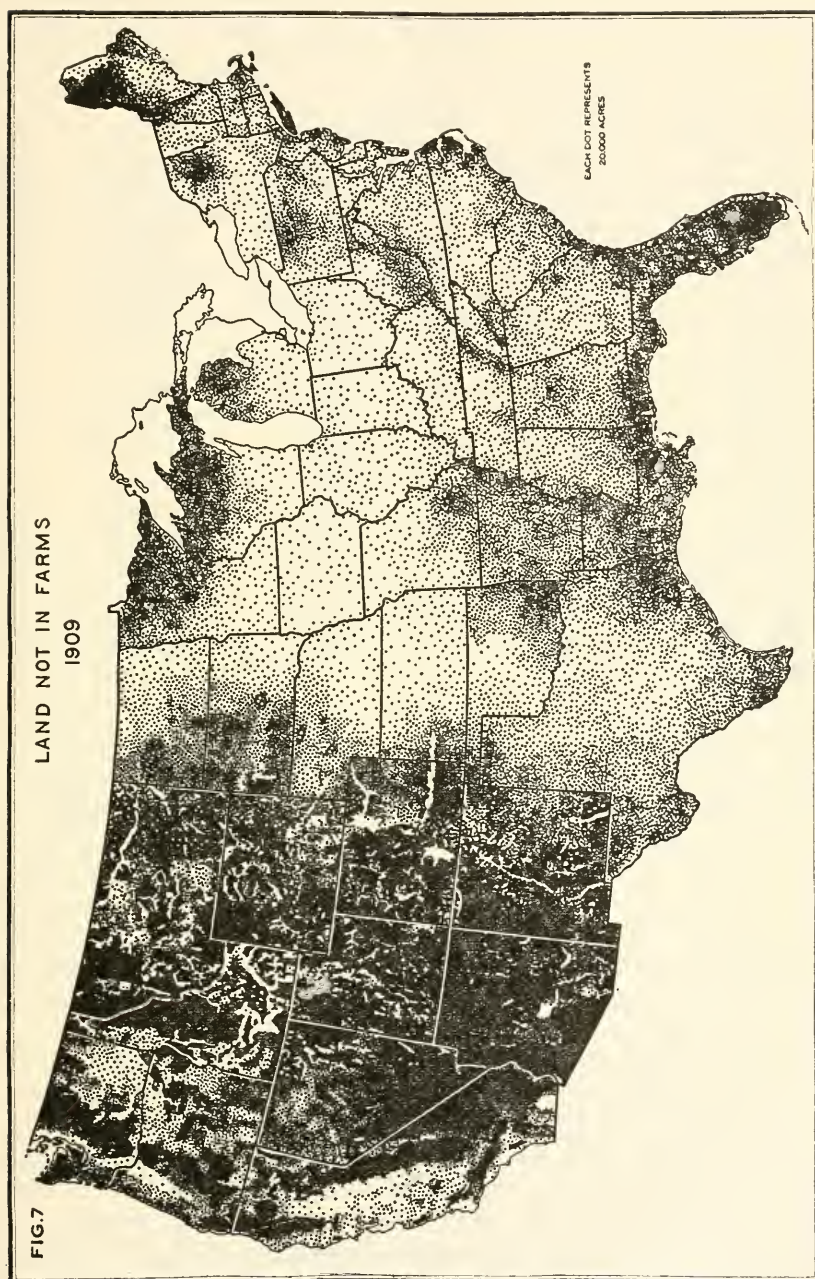
The regions of sparsest distribution of land not in crops or pasture are at the two extremes of agricultural conditions. On the one hand, there is little unused farm land in places where there are few farms, as in northern Maine and the Adirondacks, and on the

other hand, there is little unused farm land in the most fertile agricultural regions where nearly all the land in farms is utilized, as in Illinois and Iowa.

Land not in farms.—In this connection it is interesting to consider the amount and distribution of land not in farms. These figures



are derived by subtracting the land in farms as reported by the Bureau of the Census from the total land area of counties as reported by the same authority. The following table presents the results by geographic divisions and States, and figure 7 shows the distribution of land not in farms by counties:



Lands not in farms: 1910.

Division or State.	Acreage.	Per cent of total land area.	Division or State.	Acreage.	Per cent of total land area.
United States	1,024,491,275	53.8			
Geographic Divisions:			South Atlantic:		
New England	19,949,709	50.3	Delaware	218,734	17.4
Middle Atlantic	20,808,944	32.5	Maryland	1,305,100	20.5
East North Central	39,231,812	25.0	District of Columbia	32,337	81.2
West North Central	94,266,439	28.8	Virginia	6,272,044	24.3
South Atlantic	68,423,185	39.7	West Virginia	5,347,638	34.8
East South Central	33,365,131	29.0	North Carolina	8,754,471	28.1
West South Central	105,887,464	38.5	South Carolina	6,004,772	30.8
Mountain	490,306,580	89.2	Georgia	10,630,587	28.3
Pacific	152,252,011	74.8	Florida	29,857,502	85.0
New England:			East South Central:		
Maine	12,835,941	67.1	Kentucky	3,526,713	13.7
New Hampshire	2,530,382	43.8	Tennessee	6,638,023	24.9
Vermont	1,175,783	20.1	Alabama	12,086,248	36.8
Massachusetts	2,269,019	44.1	Mississippi	11,114,147	37.5
Rhode Island	239,572	35.1	West South Central:		
Connecticut	899,012	29.1	Arkansas	16,199,925	48.2
Middle Atlantic:			Louisiana	18,622,279	64.1
New York	8,468,193	27.8	Oklahoma	15,565,607	35.0
New Jersey	2,235,103	46.5	Texas	55,499,653	33.0
Pennsylvania	10,105,648	35.2	Mountain:		
East North Central:			Montana	80,023,037	85.5
Ohio	1,967,892	7.5	Idaho	48,062,956	90.1
Indiana	1,768,977	7.7	Wyoming	53,917,150	86.3
Illinois	3,344,583	9.3	Colorado	52,809,007	79.6
Michigan	17,846,586	48.5	New Mexico	67,131,899	85.6
Wisconsin	14,303,774	40.4	Arizona	71,591,787	98.3
West North Central:			Utah	49,200,061	93.5
Minnesota	24,073,297	46.5	Nevada	67,570,683	96.1
Iowa	1,644,352	4.6	Pacific:		
Missouri	9,394,032	21.4	Washington	31,062,805	72.6
North Dakota	16,490,470	36.7	Oregon	49,503,370	80.9
South Dakota	23,178,628	47.1	California	71,685,836	72.0
Nebraska	10,535,099	21.4			
Kansas	8,950,561	17.1			

The total acreage not in farms in the United States in 1909 was 1,024,491,275, or 53.8 per cent of the total land area. The greater part of this unused land was in the western half of the United States. It will be noted that in some counties in Texas there was no land not in farms reported. In fact, in these counties there was more land reported in farms than the entire land area of the counties. The reason for this discrepancy is that the farm acreage is assigned in tabulation to the county where the farmstead is located, and in these Texas counties there were many farms with farmsteads in one county and large acreages in adjoining counties.

The map in general indicates the regions where little expansion of farm acreage is possible. This is the case throughout the corn belt, in most of the spring-wheat region, and in central New York. The uncleared areas along the northern border and in Arkansas and Oklahoma appear clearly on the map, as well as the forested and marshy regions along the Gulf and South Atlantic coasts. The wheat-producing areas of eastern Washington, the Willamette Valley of western Oregon, and the valleys of California, are regions of the greatest expansion of agriculture in the West. In these localities there was comparatively little land not in farms in 1909.

In the eleven Rocky Mountain and Pacific States over 85 per cent of the land area was not in farms in 1909, and a great deal of this land is destined to remain permanently non-agricultural. Where the land is too rough for agriculture and the rainfall sufficient for the growth of trees, the land is included in the national forests, which are shown as solid black areas in figure 7. Desert areas and several Indian reservations, which had not been opened for settlement in 1909, are also shown in black.

NOTE 1.—The schedules from which the material was tabulated had been moved to a storage room and some of the schedules were lost or mislaid. The following table shows the number of the missing records and the States and counties affected:

Missing records.

State and county.	Number of farms.	Missing records.	
		Number	Per cent of total.
United States.....	6,361,502	11,877	0.19
Alabama.....	262,901	1,894	.7
Dallas.....	8,182	1,231	15.0
Lawrence.....	4,003	663	16.6
California.....	88,197	329	.4
Mariposa ¹	330	329	99.7
Colorado.....	46,170	338	.7
Custer ¹	249	247	99.2
Summit ¹	96	91	94.8
Georgia.....	291,027	1,303	.4
Haralson.....	1,925	972	50.5
Taliaferro.....	1,458	331	22.7
Iowa.....	217,044	824	.4
Pottawattamie.....	3,935	824	20.9
Minnesota.....	156,137	897	.6
Morrison.....	2,622	404	15.4
Stearns.....	4,255	493	11.6
Mississippi.....	274,382	481	.2
Bolivar.....	10,612	481	4.5
Missouri.....	277,244	753	.3
Nodaway.....	8,861	753	19.5
Nevada.....	2,689	55	2.0
Lander ¹	55	55	100.0
Ohio.....	272,045	868	.3
Putnam.....	3,469	868	25.0
Tennessee.....	246,012	1,635	.6
Houston ¹	773	772	99.8
Meigs ¹	866	863	99.6
Texas.....	417,770	83	.02
Ector ¹	84	83	98.8
Virginia.....	184,018	93	.05
Alexandria ¹	96	93	96.8
Wisconsin.....	177,127	2,324	1.3
Oconto.....	2,868	733	26.9
Vernon.....	4,003	784	19.6
Walworth.....	2,803	807	28.8

¹ Pasture figures for missing records in these counties were estimated on the basis of average acreage in adjoining counties with similar agricultural conditions.

It will be seen from the foregoing table that of the total number of 6,362,000 farms, schedules for about 12,000, or one-fifth of 1 per cent, were missing. The missing records therefore do not affect perceptibly the figures for the United States or even for any State, the largest proportion of missing records, 2 per cent, affecting the figures

for Nevada. In counties whose missing records constituted a comparatively small percentage of the total number of farms, the pasture acreage on the farms whose records were missing was estimated on the basis of averages for farms whose records were on hand. But in counties whose missing records constituted a very large proportion of the total number of farms the estimates were made on the basis of average acreage per farm for adjoining counties having similar agricultural conditions. There are, therefore, about seven counties for which the figures are estimates and possibly inaccurate, but for the remaining counties and for States and the United States the figures are as reliable as could be obtained by the method of enumeration.

NOTE 2.—By subtracting the figures for woodland pasture from those for the total woodland on farms, as reported by the census, a measure of the amount of land in woodlots not pastured could have been obtained if it were not for the difference in definitions. The census definition of woodland pasture is given on page 1, and woodland on farms was defined as follows:

Woodland in this farm. (Give here land covered with natural or planted forest trees, whose principal value is in firewood, timber, or other forest products, which it will now or later yield.)

Woodland pasture, therefore, according to the definition, includes a large territory of open pasture with scattered trees, and naturally this territory would not be reported as woodland. As a matter of fact the acreage reported for woodland pasture was, in many counties, and even in many States, considerably in excess of the total acreage for woodland. Nevertheless, it was considered worth while to show in Table I the percentage of farm land not used for crops or pasture which was in woodland and in all other kinds of land not otherwise specified, with the understanding that these figures are only rough approximations.

In the case of a few counties the reported pasture land is greater than the entire farm land, exclusive of land in crops, and in some others pasture land alone, as reported, is greater than the total land in farms. These discrepancies probably are due to the fact that in some cases, especially in the range States, the farmer would report as pasture a great deal of range land that he did not report as part of his farm. It was deemed advisable to let the reports stand as made, because there was no evidence on which to base any editorial revision. It will be understood, therefore, that these paradoxical returns are presented exactly as made by the enumerators. The following table gives the list of counties from which an excessive acreage in pasture was reported and the amount of the excess. This excess makes it obvious that the figures given for these counties in the column headed "All other farm land" were minus quantities.

In Table II the minus quantities are not given, but a reference is made to this list. The State totals for this column equal the sum of the figures shown for counties less the minus quantities reported for the counties here listed.

Counties reporting an excessive acreage in pasture.

State.	County.	Excess.	State.	County.	Excess.
		<i>Acres.</i>			<i>Acres.</i>
California.....	Tuolumne	91,641	South Dakota.....	Todd.....	3,194
Colorado.....	Jefferson.....	13,774	Texas.....	Aransas.....	14
Illinois.....	Madison.....	11,322		Crockett.....	769,533
Indiana.....	Ripley.....	6,504		Hartley.....	54,803
Iowa.....	Cherokee.....	55,575		Kinney.....	6,225
	O'Brien.....	75,456		Llano.....	8,978
Kansas.....	Clark.....	130,801		McCulloch.....	23,949
	Greeley.....	15,994		Mason.....	32,466
Louisiana.....	Lafayette.....	21,662		Roberts.....	71,335
Nebraska.....	Banner.....	1,366		Scurry.....	129,293
	Hooker.....	19,301		Victoria.....	279,258
Nevada.....	Elko.....	445,998		Wheeler.....	62,989
	Washoe.....	33,150		Yoakum.....	3,436
North Dakota.....	Mountrail.....	31,900	Virginia.....	Clifton Forge City...	23
South Dakota.....	Mellette.....	2,603	Wyoming.....	Sweetwater.....	361,711

TABLE I.—*Pasture land on farms in the United States, by geographic divisions and States (1910 census).*

Division and State.	Total land in farms.	Land in crops.	Pasture land.			All other farm land.	Percentage of total farm land devoted to—						Acres in pasture per 100 acres in crops.			
			Total.	Improved.	Unimproved.		Crops.	Pasture.			Other purposes.					
					Wood-land.			Other.	Total.	Im-proved.		Wood-land.		Total.	Woods not pas-tured.	All other.
United States.....	878, 798, 325	318, 518, 917	291, 439, 515	84, 226, 304	98, 445, 168	108, 768, 043	268, 839, 893	36.2	33.2	9.6	11.2	12.4	30.6	10.4	20.2	91.5
Geographic divisions:																
New England:																
Maine.....	6, 296, 859	1, 715, 453	1, 935, 123	323, 965	1, 007, 776	603, 382	2, 646, 283	27.2	30.7	5.1	16.0	9.6	42.1	28.1	14.0	112.8
New Hampshire.....	3, 249, 458	635, 362	1, 211, 772	79, 949	782, 227	349, 596	1, 402, 324	19.6	37.3	2.5	24.1	10.7	43.1	22.1	21.0	190.7
Vermont.....	4, 663, 577	1, 244, 071	2, 274, 161	376, 328	951, 391	946, 442	1, 445, 345	26.7	48.8	8.1	20.4	20.3	24.5	11.3	182.8	
Massachusetts.....	2, 876, 941	708, 762	926, 758	150, 392	475, 970	300, 396	1, 240, 421	24.6	32.2	5.2	16.6	10.4	43.2	20.5	22.7	130.8
Rhode Island.....	443, 308	128, 704	128, 704	39, 876	99, 094	228, 581	203, 581	20.5	29.0	9.0	13.5	6.5	50.5	28.4	22.1	141.4
Connecticut.....	2, 185, 788	572, 409	1, 161, 133	173, 030	377, 051	206, 072	797, 226	26.2	37.3	7.9	17.2	12.2	36.5	17.4	19.1	142.6
Middle Atlantic:																
New York.....	22, 030, 367	8, 949, 592	7, 501, 640	3, 098, 982	2, 417, 633	1, 985, 025	5, 579, 135	40.6	34.1	14.1	11.0	9.0	25.3	9.2	16.1	83.8
New Jersey.....	2, 573, 837	1, 190, 701	433, 188	225, 770	101, 705	105, 713	949, 968	46.3	16.8	8.8	3.9	4.1	36.9	16.9	20.0	36.4
Pennsylvania.....	18, 586, 832	8, 224, 299	4, 330, 126	1, 798, 923	1, 612, 309	938, 894	6, 012, 407	44.2	23.4	9.7	8.7	5.0	32.4	14.4	18.0	52.9
East North Central:																
Ohio.....	24, 105, 708	11, 843, 259	7, 973, 822	4, 536, 624	2, 284, 829	1, 152, 369	4, 288, 627	49.1	33.1	18.8	9.5	4.8	17.8	4.2	13.6	67.3
Indiana.....	21, 299, 823	11, 506, 323	5, 686, 469	2, 531, 771	2, 418, 642	716, 056	4, 107, 031	54.0	26.7	12.0	11.4	3.3	19.3	4.5	14.8	49.4
Illinois.....	32, 522, 937	20, 523, 978	7, 636, 546	4, 081, 506	2, 550, 782	1, 004, 258	4, 362, 413	63.1	23.5	12.5	7.9	3.1	13.4	1.8	11.6	37.2
Michigan.....	18, 940, 614	8, 589, 899	5, 333, 751	1, 392, 743	2, 424, 930	1, 546, 078	5, 016, 964	45.4	28.2	7.2	12.8	8.2	26.4	2.7	23.7	62.1
Wisconsin.....	21, 660, 066	8, 617, 542	7, 775, 602	1, 699, 127	4, 171, 617	1, 904, 838	4, 666, 922	40.9	36.9	8.0	19.8	9.1	22.2	5.8	16.4	90.2
West North Central:																
Minnesota.....	27, 675, 823	14, 778, 337	6, 591, 439	2, 006, 150	2, 905, 559	1, 679, 730	6, 306, 047	53.4	23.8	7.2	10.5	6.1	22.8	3.7	19.1	44.6
Iowa.....	33, 980, 688	20, 632, 138	10, 635, 616	6, 271, 197	2, 900, 007	1, 734, 412	2, 742, 384	60.5	31.4	18.5	7.8	5.1	8.1	.....	8.1	51.9
Missouri.....	34, 391, 248	14, 706, 471	10, 781, 515	5, 534, 034	4, 384, 280	863, 201	9, 108, 262	42.5	31.2	16.0	12.7	2.5	26.3	.....	13.1	73.3

North Dakota.....	28,426,650	15,890,793	4,386,286	1,635,384	350,998	2,399,904	8,149,571	55.9	15.4	5.7	1.2	8.5	28.7	28.7	27.6
South Dakota.....	26,016,892	12,243,660	8,148,371	3,066,616	442,874	4,638,881	5,625,461	47.1	31.3	11.8	1.7	17.8	21.6	21.6	66.6
Nebraska.....	38,622,021	17,318,011	16,398,680	4,552,087	1,282,722	10,563,871	4,903,340	44.8	42.5	11.8	3.3	27.4	12.7	12.7	94.7
Kansas.....	43,841,799	20,093,126	17,115,638	5,925,580	1,644,363	9,542,655	6,176,035	46.3	39.5	13.7	3.9	21.9	14.2	14.2	85.2
South Atlantic:															
Delaware.....	1,038,866	474,303	103,679	67,463	15,475	20,741	460,684	45.7	10.0	6.5	1.5	2.0	44.3	22.8	21.5
Maryland.....	5,057,140	2,066,078	839,269	496,033	233,925	129,251	2,191,853	39.7	17.0	9.8	4.6	2.6	43.3	24.4	18.9
District of Columbia.....	6,063	3,048	1,241	1,100	129	12	1,774	50.3	20.4	18.2	2.2	.....	9.2	20.1	40.7
Virginia.....	19,495,636	4,514,027	4,428,410	2,335,360	1,544,914	498,136	10,553,199	23.2	22.7	22.2	7.9	2.6	54.1	35.2	18.9
West Virginia.....	10,026,442	2,066,648	3,484,060	2,252,876	714,584	516,600	14,457,830	26.6	34.7	22.5	7.1	5.1	44.7	32.5	168.6
North Carolina.....	22,439,129	5,924,906	2,056,413	567,532	1,194,679	294,202	14,457,830	26.6	34.7	22.5	7.1	5.1	44.7	32.5	168.6
South Carolina.....	13,512,028	5,193,174	1,286,912	154,452	933,086	179,374	7,031,942	38.4	9.5	1.2	7.0	1.3	52.0	39.9	14.3
Georgia.....	9,860,964	2,937,390	2,537,390	313,305	1,936,233	267,861	14,555,050	36.5	9.4	1.1	7.3	1.0	51.1	41.0	24.8
Florida.....	5,253,538	1,320,450	578,742	51,034	410,765	116,943	3,354,346	25.1	11.0	1.0	7.8	2.2	63.9	49.4	43.8
East South Central:															
Kentucky.....	22,189,127	6,253,012	5,810,585	3,828,564	1,388,819	593,352	10,125,359	28.2	26.2	17.3	6.2	2.7	45.6	25.0	20.6
Tennessee.....	20,041,657	6,569,175	3,694,451	1,632,552	1,624,215	407,684	9,811,031	32.8	18.3	8.2	8.1	2.0	48.9	31.8	55.8
Alabama.....	20,732,312	7,304,708	2,550,100	554,996	1,716,732	278,372	10,877,506	35.2	12.3	2.7	8.2	1.4	52.5	37.3	34.9
Mississippi.....	18,557,533	6,218,052	3,392,156	882,199	2,026,553	483,424	8,947,325	33.5	18.3	4.8	10.9	2.6	48.2	31.6	54.6
West South Central:															
Arkansas.....	17,416,075	5,650,084	1,716,950	498,368	1,037,025	181,557	10,049,041	32.4	9.9	2.9	6.0	1.0	57.7	42.9	30.4
Louisiana.....	10,439,481	3,613,542	1,348,664	479,152	677,964	191,548	5,477,277	34.6	12.9	4.6	6.5	1.8	52.5	34.7	37.3
Oklahoma.....	28,859,353	12,092,476	10,013,450	2,581,390	3,008,187	4,423,873	6,753,427	41.8	34.7	8.9	10.4	15.4	23.5	21.5	82.8
Texas.....	112,435,067	18,665,865	63,523,701	7,427,840	30,698,745	25,397,116	30,245,499	16.6	56.5	6.6	27.3	22.6	26.9	26.9	340.3
Mountain:															
Montana.....	13,545,603	1,822,725	7,251,087	1,900,159	899,014	4,451,914	4,411,791	13.9	53.5	14.0	6.6	32.9	32.6	32.0	385.1
Idaho.....	5,283,604	1,691,491	1,272,604	271,348	375,418	625,838	2,319,569	32.0	24.1	5.1	7.1	11.9	43.9	3.9	73.2
Wyoming.....	8,543,010	788,435	5,337,249	653,167	583,977	4,100,105	2,417,326	9.2	62.5	7.7	6.8	48.0	28.3	28.3	676.9
Colorado.....	13,532,113	2,691,909	7,366,653	1,337,794	1,088,356	4,940,503	3,475,551	19.9	54.4	9.9	8.0	36.5	25.7	25.7	273.6
New Mexico.....	11,270,021	660,782	6,940,017	1,090,127	1,323,464	4,526,426	3,693,222	5.9	61.6	9.6	11.8	40.2	32.5	31.0	1,060.3
Arizona.....	1,246,613	106,011	467,677	77,353	102,738	287,566	582,918	13.7	37.5	6.2	8.2	23.1	46.8	1.9	44.9
Utah.....	3,897,690	704,286	1,365,376	271,945	225,241	838,190	1,241,037	23.3	40.2	8.0	7.5	24.7	36.5	36.0	238.6
Nevada.....	2,714,757	394,159	2,204,671	989,973	255,555	1,069,143	53,927	14.5	83.4	34.6	9.4	39.4	2.1	2.1	574.6
Pacific:															
Washington.....	11,712,235	3,604,995	3,373,864	390,098	965,331	2,018,435	4,733,376	30.8	28.8	3.3	8.2	17.3	40.4	4.9	35.5
Oregon.....	11,685,110	2,406,832	5,347,452	716,273	1,608,467	2,962,712	3,930,726	20.6	45.8	6.1	14.3	25.4	33.6	4.9	28.7
California.....	27,931,414	5,707,864	15,035,433	2,913,949	6,445,256	5,676,228	7,188,147	20.4	54.0	10.5	23.2	20.3	25.6	25.6	264.1
Hawaii.....	2,590,600	216,932	1,394,017	46,914	492,285	854,818	979,651	8.4	53.8	1.8	19.0	33.0	37.8	4.0	642.6

TABLE II.—*Pasture land on farms in the United States, by counties (1910 census).*

County.	Total land in farms.	Land in crops.	Pasture land.				All other farm land.	Percentage of total farm land de- voted to—		Acres in pasture per 100 acres in crops.
			Total.	Improved.	Woodland.	Other.		Crops.	Pasture.	
ALABAMA.										
Autauga.....	245,668	91,206	21,105	2,738	17,620	747	133,357	37.1	8.6	23.1
Baldwin.....	152,938	24,201	19,034	12,543	13,293	5,198	109,703	15.8	12.4	78.5
Barbour.....	423,587	184,327	55,619	12,915	36,127	6,377	183,641	43.5	13.1	30.2
Bibb.....	181,213	48,128	14,736	3,822	10,592	322	118,349	26.6	8.1	30.6
Blount.....	297,897	86,765	43,376	11,871	29,845	1,660	167,756	29.1	14.6	50.0
Bullock.....	297,384	173,641	23,399	8,310	12,782	2,307	100,344	58.4	7.9	13.5
Butler.....	338,358	125,532	26,577	4,504	19,063	3,010	186,249	37.1	7.9	21.2
Calhoun.....	288,143	83,037	36,514	4,221	27,321	4,972	138,592	32.2	14.1	44.0
Chambers.....	333,997	157,351	50,959	11,567	29,399	10,083	125,687	29.4	15.3	32.4
Cherokee.....	282,319	83,331	31,477	6,776	21,931	2,747	168,511	40.1	11.1	37.8
Chilton.....	263,893	85,790	17,897	3,790	10,936	3,171	160,206	32.5	6.8	41.4
Choctaw.....	331,488	72,869	30,190	8,116	18,877	3,197	228,429	22.0	9.1	41.4
Clarke.....	480,656	101,467	34,648	7,728	23,083	3,837	350,541	20.8	7.1	34.2
Clay.....	255,330	77,070	36,876	10,290	21,007	5,579	141,384	30.2	14.4	47.8
Cleburne.....	200,888	47,768	19,735	5,547	12,354	1,834	133,385	23.8	9.8	41.3
Coffee.....	337,920	147,996	53,282	7,335	44,090	1,857	156,642	41.3	14.9	36.0
Colbert.....	233,360	85,818	19,300	6,307	11,684	1,249	128,242	36.8	8.3	22.5
Conecuh.....	299,779	90,605	15,739	2,773	12,598	368	163,435	33.6	5.8	17.3
Coosa.....	272,964	71,740	53,128	9,123	34,480	9,525	148,096	26.3	19.5	74.1
Covington.....	315,240	112,971	44,611	8,008	43,592	211	157,658	35.9	14.2	39.5
Crenshaw.....	309,836	127,138	47,507	5,766	31,819	9,922	135,191	41.0	15.3	37.4
Cullman.....	343,008	108,658	49,375	12,382	30,745	6,248	184,975	31.7	14.4	45.4
Dale.....	314,874	122,198	45,943	10,384	30,586	4,973	146,733	38.8	14.6	37.6
Dallas.....	392,745	212,082	40,782	49,423	26,302	5,057	109,881	58.5	11.2	19.2
DeKalb.....	363,521	112,252	44,313	13,368	28,685	6,260	206,956	30.9	12.2	38.5
Elmore.....	296,754	110,689	53,112	6,913	39,791	6,408	132,953	37.4	17.9	48.0
Escambia.....	127,034	35,766	12,659	2,282	11,157	1,270	78,609	28.2	10.0	35.4
Etowah.....	249,368	75,473	38,505	7,558	28,274	2,673	135,390	30.3	15.4	51.0
Fayette.....	296,019	68,258	39,283	8,754	26,966	3,563	188,478	23.1	13.3	57.5
Franklin.....	256,827	66,009	26,937	5,181	17,601	4,555	163,881	25.7	10.5	40.8
Geneva.....	275,606	122,146	7,721	873	5,935	913	145,739	44.3	2.8	6.3
Greene.....	279,575	113,060	32,169	8,767	17,615	5,787	134,346	40.4	11.5	28.5
Hale.....	328,705	138,462	68,344	19,456	38,346	5,542	126,899	42.1	19.2	45.9
Henry.....	306,069	129,454	28,842	4,471	21,248	3,423	147,773	42.3	9.4	22.2
Houston.....	324,608	154,732	6,460	2,083	3,714	663	163,416	27.1	2.0	4.2
Jackson.....	443,289	120,223	33,634	13,095	16,770	3,769	289,432	27.1	7.6	28.0
Jefferson.....	305,820	68,333	18,748	4,755	12,196	1,797	184,739	29.0	8.0	27.4
Lamar.....	313,065	71,372	56,720	9,460	38,449	8,811	148,973	22.8	18.1	79.5
Lauderdale.....	345,502	118,815	23,138	5,726	14,235	3,177	203,549	34.5	6.7	19.4

Lawrence.....	311,481	112,720	a,35,764	a,10,431	a,23,271	a,2,062	162,997	36.0	11.5	31.7
Lee.....	318,199	130,856	47,612	9,960	26,427	11,255	139,701	41.1	13.0	36.4
Limestone.....	298,393	120,834	21,798	6,278	13,820	1,700	155,761	40.5	7.3	18.0
Lowndes.....	307,889	168,491	26,381	7,768	16,336	2,280	134,014	54.6	8.5	13.7
Macon.....	251,265	137,765	19,472	2,580	13,377	1,615	94,028	55.0	7.7	14.2
Madison.....	408,781	184,067	54,212	18,610	30,428	5,174	170,502	46.1	13.3	21.5
Marengo.....	435,389	166,074	86,168	22,639	34,656	8,853	201,147	36.6	19.0	51.9
Marion.....	318,328	67,066	38,264	11,080	25,127	2,057	212,998	21.1	12.0	57.1
Marshall.....	330,132	118,564	41,966	12,890	26,272	2,804	169,602	35.9	12.7	35.4
Mobile.....	144,460	17,280	108,719	1,293	105,491	1,435	18,511	11.9	75.3	68.1
Monroe.....	343,289	114,543	43,274	8,086	33,489	1,699	281,472	26.1	9.8	37.8
Montgomery.....	385,686	228,559	35,880	11,126	19,187	5,507	119,247	59.6	14.2	15.7
Morgan.....	294,200	96,777	41,741	12,257	23,550	5,934	155,682	32.9	9.4	43.1
Perry.....	356,740	146,062	43,068	10,769	24,745	7,554	167,610	40.9	12.1	20.5
Pickens.....	370,291	111,869	65,655	8,586	49,093	7,976	192,767	30.2	17.7	58.7
Pike.....	364,844	181,904	45,279	9,994	29,128	7,007	137,661	49.9	12.4	24.9
Randolph.....	302,254	103,922	41,885	12,601	21,121	7,663	156,947	34.4	13.7	39.8
Russell.....	266,784	137,731	40,435	5,806	28,306	6,323	88,618	31.6	15.2	29.4
Saint Clair.....	227,615	56,065	21,789	3,772	16,150	807	149,761	24.6	9.6	38.8
Shelby.....	279,119	67,544	14,391	3,458	10,311	622	137,181	24.2	5.2	21.3
Sumter.....	371,231	134,713	71,135	25,059	37,404	8,012	165,443	36.3	19.2	52.8
Talladega.....	283,084	125,889	31,156	4,113	24,103	2,940	126,039	44.5	11.0	24.8
Tallapoosa.....	400,193	135,158	73,168	15,447	46,858	10,863	191,867	33.8	18.3	54.2
Tuscaloosa.....	450,211	124,055	58,821	10,157	36,485	7,179	272,335	27.5	12.0	43.4
Walker.....	250,003	58,191	20,392	6,837	11,306	2,249	171,420	23.3	8.1	35.0
Washington.....	344,620	28,904	32,941	1,422	29,876	1,643	282,775	8.4	9.6	114.0
Wilcox.....	378,130	155,239	61,874	19,643	37,139	5,092	161,017	41.0	16.3	36.8
Winston.....	255,394	47,181	14,983	4,123	10,125	6,685	193,280	18.5	5.8	31.6
Total.....	20,732,312	7,304,706	2,550,100	554,996	1,716,732	278,372	10,877,506	35.2	12.3	34.9

ARIZONA.

Apache.....	104,859	7,596	26,286	2,613	1,575	22,048	71,027	7.2	25.0	345.4
Cochise.....	369,985	12,871	124,306	17,999	23,369	82,927	172,808	4.2	40.1	965.8
Cocumino.....	29,004	3,220	15,145	1,510	6,629	7,006	10,689	11.1	38.7	470.3
Gila.....	22,006	3,495	8,514	1,031	3,488	3,995	9,997	15.9	52.1	243.6
Graham.....	72,760	24,268	7,581	1,789	1,610	4,182	40,911	10.4	10.4	31.2
Maricopa.....	248,271	95,279	58,246	38,729	11,563	7,924	94,746	38.4	23.5	61.1
Mohave.....	4,000	552	920	400	560	.....	2,618	13.5	22.5	166.7
Navajo.....	105,589	7,364	16,921	723	5,621	10,577	81,304	7.0	16.0	299.8
Pima.....	71,937	6,403	37,694	1,282	21,113	12,299	27,840	8.9	52.4	588.7
Pinal.....	13,164	13,028	3,950	2,624	6,448	6,448	16,557	31.5	30.2	93.7
Santa Cruz.....	51,871	4,684	38,126	3,768	3,768	34,123	9,064	9.0	73.5	814.0
Yavapai.....	130,434	10,023	113,811	4,865	13,917	95,029	26,000	6.6	75.7	113.5
Yuma.....	32,555	6,649	7,149	2,221	3,900	1,028	18,757	20.4	22.0	107.5
Total.....	1,246,613	196,018	467,677	77,353	102,738	287,586	582,918	15.7	37.5	238.6

a Estimated.

TABLE II.—*Pasture land on farms in the United States, by counties (1910 census)*—Continued.

County.	Total land in farms.	Land in crops.	Pasture land.					All other farm land.	Percentage of total farm land de- voted to—		Acres in pasture per 100 acres in crops.
			Total.	Improved.	Woodland.	Other.	Crops.		Pasture.		
ARKANSAS.											
Arkansas.....	300,417	80,881	48,149	23,398	15,290	9,461	171,387	26.9	16.0	59.5	
Ashley.....	233,906	16,946	16,946	4,996	11,135	815	136,163	34.5	7.2	21.0	
Baxter.....	184,199	37,370	32,698	2,805	7,512	22,281	114,231	20.3	17.7	87.2	
Benton.....	167,308	89,064	28,848	52,456	26,318	7,760	176,037	38.7	20.6	63.2	
Boone.....	249,800	67,321	44,191	16,005	26,318	1,868	138,348	26.9	17.7	55.6	
Bradley.....	141,411	33,952	10,644	3,121	5,974	1,549	96,805	24.0	7.5	31.3	
Calhoun.....	135,367	35,667	14,584	2,744	6,699	5,141	85,116	26.3	10.8	40.9	
Carroll.....	277,748	71,255	49,352	16,314	30,310	2,728	137,141	25.7	17.8	69.3	
Cheicot.....	176,043	69,726	23,574	4,285	16,291	2,998	82,743	39.6	13.4	33.8	
Clark.....	204,866	65,843	31,941	6,826	21,297	3,818	167,082	24.9	12.1	48.5	
Clay.....	186,195	85,816	15,045	7,539	6,896	700	85,334	46.1	8.1	17.5	
Cleburne.....	185,906	40,677	8,478	2,514	4,784	1,180	136,751	21.9	4.6	20.8	
Cleveland.....	197,327	43,301	14,031	6,890	6,151	990	139,995	21.9	7.1	32.4	
Columbia.....	346,900	107,058	16,303	2,855	13,017	431	223,629	30.9	4.7	15.2	
Conway.....	250,612	111,462	22,762	11,040	10,642	1,080	116,388	44.5	9.1	20.4	
Craighead.....	132,005	79,082	23,454	6,003	16,161	690	89,469	41.2	12.2	29.7	
Crawford.....	236,453	81,701	18,788	4,042	11,909	2,837	135,964	34.6	7.9	20.7	
Crittenden.....	137,876	84,975	3,219	4,901	2,500	168	49,682	61.6	2.3	3.8	
Cross.....	126,266	41,549	5,397	1,368	3,896	223	79,320	32.9	4.3	13.0	
Dallas.....	164,540	32,308	6,525	2,651	4,227	247	125,707	19.6	4.0	20.2	
Desha.....	177,169	48,607	991	411	288	292	127,571	27.4	.6	2.0	
Drew.....	303,146	78,154	24,613	10,459	11,696	2,458	200,379	25.8	8.1	31.5	
Faulkner.....	299,614	109,912	30,467	11,122	15,785	3,560	159,235	36.7	10.2	27.7	
Franklin.....	262,976	98,377	49,011	17,570	26,375	5,066	115,588	37.4	18.6	49.8	
Fulton.....	253,982	58,083	24,649	6,309	14,686	3,654	176,250	22.4	9.5	42.4	
Garland.....	168,382	31,194	11,701	2,508	6,954	2,239	125,487	18.5	6.9	37.5	
Grant.....	122,134	32,147	6,947	2,522	3,835	2,590	83,040	26.3	5.7	21.6	
Greene.....	204,403	82,373	16,693	6,479	8,101	2,113	105,337	40.3	8.2	20.3	
Hempstead.....	304,335	121,513	38,903	9,037	24,237	5,629	143,919	39.9	12.8	32.0	
Hot Spring.....	178,325	43,761	8,899	2,090	5,855	864	125,755	24.5	4.9	20.1	
Howard.....	211,271	69,429	22,630	6,663	15,430	537	119,212	32.9	10.7	32.6	
Independence.....	305,365	106,924	23,847	8,468	13,503	1,576	175,894	34.7	7.7	22.2	
Izard.....	274,644	59,681	20,776	10,732	8,801	1,243	194,187	21.7	7.6	34.8	
Jackson.....	213,250	96,427	15,596	694	14,054	848	101,227	45.2	7.3	16.2	
Jefferson.....	355,161	143,308	7,716	1,231	6,103	412	204,107	40.3	2.2	5.4	
Johnson.....	230,961	88,757	10,092	2,661	21,661	531	109,920	38.4	14.0	36.4	
Lafayette.....	151,383	47,420	11,939	2,880	8,664	395	92,024	31.3	7.9	25.2	

Lawrence.....	215,295	75,604	24,596	7,337	14,641	2,618	115,095	35.1	11.4	32.5
Lee.....	206,572	106,434	5,953	1,559	3,996	398	94,185	51.5	2.9	5.6
Lincoln.....	216,241	68,924	13,006	5,182	8,330	94	133,711	31.9	6.3	19.7
Little River.....	164,618	50,238	19,981	3,856	14,010	2,115	94,399	30.5	12.1	39.8
Logan.....	316,138	124,151	52,528	13,434	32,858	6,236	139,459	39.3	10.6	42.3
Lonoke.....	287,691	120,399	31,357	11,151	19,123	1,083	135,735	41.9	10.9	26.0
Madison.....	363,641	79,550	39,213	16,575	20,973	1,665	244,878	21.9	10.8	49.3
Marion.....	166,223	42,738	15,833	3,792	10,977	1,064	107,652	25.7	9.5	37.0
Miller.....	181,636	53,907	14,357	2,824	10,083	1,495	113,372	29.7	7.9	26.6
Mississippi.....	173,747	106,911	1,558	268	1,285	5	71,278	50.5	2.9	1.5
Monroe.....	141,800	72,094	3,021	455	2,971	195	66,055	30.8	2.6	5.0
Montgomery.....	225,806	45,510	10,405	2,566	6,791	1,048	109,891	20.2	4.6	22.9
Nevada.....	280,073	87,353	34,869	12,372	17,904	4,593	157,851	31.2	12.4	39.9
Newton.....	229,723	39,793	8,408	4,349	3,125	994	181,462	17.3	3.7	21.3
Ouachita.....	259,715	67,214	18,561	3,674	11,996	2,891	173,940	25.9	7.1	27.6
Perry.....	80,683	31,894	4,215	1,589	2,265	361	53,574	35.6	4.7	13.2
Phillips.....	217,669	117,012	9,350	2,492	6,454	404	91,307	53.7	4.3	8.0
Pike.....	165,290	41,027	14,970	5,341	8,988	641	109,302	24.8	9.1	36.5
Poinsett.....	101,370	35,379	17,229	1,978	14,260	991	48,762	34.9	17.0	48.7
Polk.....	249,169	48,444	20,063	3,484	16,014	565	180,662	19.4	8.1	41.4
Prairie.....	240,516	112,035	31,987	12,217	19,299	471	146,434	38.6	11.0	28.5
Pulaski.....	189,471	71,432	22,047	8,684	10,001	3,062	95,982	37.7	11.6	30.9
Purdell.....	257,252	90,677	27,861	9,692	28,179	2,290	101,920	41.9	15.5	36.2
Randolph.....	177,858	95,033	5,856	1,229	13,498	1,549	76,969	53.4	3.3	6.2
St. Francis.....	223,210	51,977	11,062	1,619	7,202	2,241	160,171	23.3	5.0	21.3
Saline.....	227,127	59,311	24,864	3,640	16,971	4,253	142,952	20.5	10.9	41.9
Scott.....	246,457	47,976	10,279	4,207	5,300	772	188,202	19.5	4.2	21.4
Searey.....	222,187	85,802	45,083	8,066	34,089	2,328	91,242	38.6	20.3	52.5
Sevier.....	218,222	60,111	20,112	3,654	13,405	3,053	137,999	27.5	9.2	33.5
Sharp.....	201,199	57,063	32,972	12,266	19,809	897	171,164	21.8	12.6	57.8
Stone.....	355,599	35,509	22,354	2,817	12,415	7,122	145,256	17.5	11.0	63.0
Union.....	415,917	99,297	40,398	9,480	29,991	927	276,232	23.9	9.7	40.7
Van Buren.....	272,681	62,204	13,204	5,793	5,389	1,842	197,273	22.8	4.8	21.2
Washington.....	473,823	178,579	84,193	23,142	55,548	5,503	211,051	37.7	17.8	47.1
White.....	329,128	100,764	35,576	10,281	22,931	2,364	192,788	30.6	10.8	35.3
Woodruff.....	136,107	83,729	9,500	1,810	6,483	1,207	62,878	33.6	6.1	11.3
Yell.....	252,748	110,433	40,055	4,522	24,465	11,068	132,260	33.1	14.2	36.3
Total.....	17,416,075	5,650,084	1,716,950	498,368	1,037,025	181,557	10,049,041	32.4	9.9	30.4

CALIFORNIA.

Alameda.....	311,327	121,983	143,280	22,682	62,871	57,727	46,064	39.2	46.0	117.5
Alpine.....	32,004	4,710	12,824	1,377	8,616	2,831	14,470	14.7	40.0	272.3
Amador.....	291,730	19,397	240,505	25,473	178,209	36,823	31,628	6.7	82.4	1,227.3
Butte.....	490,777	110,535	245,911	71,808	132,595	134,331	134,331	22.5	50.1	222.5
Calaveras.....	271,401	17,504	246,681	39,810	165,703	41,168	7,216	6.4	90.9	1,409.3
Colusa.....	522,376	139,766	207,308	62,397	67,809	77,102	175,302	26.8	39.7	148.3

TABLE II.—*Pasture land on farms in the United States, by counties (1910 census)*—Continued.

County.	Total land in farms.	Land in crops.	Pasture land.			All other farm land.	Percentage of total farm land devoted to—		Acres in pasture per 100 acres in crops.
			Total.	Improved.	Woodland.		Crops.	Pasture.	
Contra Costa.....	406,433	141,681	181,760	55,894	34,196	91,670	82,992	34.9	128.3
Del Norte.....	35,947	3,484	24,820	5,823	7,355	11,612	7,643	69.1	712.4
Eldorado.....	210,881	17,180	141,776	5,624	127,233	8,619	52,225	9.7	241.4
Fresno.....	1,106,616	271,257	329,776	126,339	247,935	134,842	305,583	8.1	195.3
Glenn.....	101,341	265,282	93,951	93,951	92,792	178,539	124,573	20.6	261.8
Humboldt.....	612,536	39,249	370,137	91,087	108,750	175,300	233,150	6.1	943.1
Imperial.....	223,602	110,608	29,430	28,133	191	1,056	83,564	49.5	26.6
Inyo.....	110,142	22,354	51,468	14,952	797	35,739	36,320	20.3	230.2
Kern.....	1,403,350	112,479	591,754	65,476	207,180	319,098	699,117	8.0	526.1
Kings.....	373,823	115,120	177,350	67,052	10,512	99,786	81,353	30.8	154.1
Lake.....	217,464	22,927	160,909	7,820	73,592	79,497	33,628	10.5	74.0
Lassen.....	295,728	78,257	150,206	38,462	29,365	82,379	67,265	26.5	50.8
Los Angeles.....	757,985	298,837	76,863	14,288	25,726	36,849	382,285	39.4	10.1
Madera.....	620,663	163,738	227,143	121,624	58,545	46,974	229,782	26.4	138.7
Marin.....	263,412	19,673	119,895	50,040	1,716	68,139	123,874	7.5	609.5
Mariposa.....	206,059	8,148	a 108,911	a 25,375	a 136,402	a 93,134	(b)	4.4	2,152.4
Mendocino.....	721,325	43,291	561,784	23,970	238,508	239,306	116,250	6.0	1,997.6
Merced.....	1,102,167	205,785	571,353	34,519	37,132	219,402	385,029	17.8	277.6
Modoc.....	410,134	96,487	272,273	39,598	107,715	124,960	41,374	23.5	282.2
Mono.....	115,672	7,351	94,139	32,742	23,183	38,214	14,182	6.4	81.4
Monterey.....	1,147,416	240,346	837,105	67,700	411,459	357,946	69,965	20.9	348.4
Napa.....	380,580	61,392	233,090	31,380	158,016	44,294	65,498	17.0	380.7
Nevada.....	11,923	141,568	6,637	124,041	10,870	22,807	22,807	6.3	128.5
Orange.....	371,692	142,717	126,774	11,628	113,342	102,201	102,201	38.4	88.8
Placer.....	218,080	47,262	166,118	41,733	112,106	31,700	31,700	19.1	351.5
Plumas.....	35,378	77,833	9,749	14,875	53,209	21,048	26.4	58.0	220.0
Riverside.....	520,806	188,728	129,142	16,519	13,437	99,186	292,936	36.2	68.4
Sacramento.....	473,044	117,782	217,848	97,821	54,709	65,318	137,413	24.9	185.0
San Benito.....	544,301	84,882	312,924	61,778	124,156	158,990	116,495	15.6	404.0
San Bernardino.....	298,396	99,956	25,735	5,591	11,651	8,933	82,705	48.0	25.7
San Diego.....	834,563	134,563	556,423	43,955	71,318	441,150	143,440	16.1	413.4
San Francisco.....	2,091	727	316	401	110	165	1,048	34.8	43.5
San Joaquin.....	362,960	200,300	110,201	46,852	43,247	199,788	47,001	37.6	55.2
San Luis Obispo.....	1,588,680	133,663	976,996	37,569	503,101	386,326	48,001	8.4	730.9
San Mateo.....	160,655	42,323	72,976	33,857	15,423	23,696	45,356	26.3	172.4
Santa Barbara.....	1,120,475	134,105	631,261	73,038	315,879	220,344	317,109	12.0	476.7
Santa Clara.....	731,819	168,516	459,064	21,954	313,323	123,757	107,239	22.9	272.5

CALIFORNIA—Continued.

Santa Cruz.....	157,308	44,625	51,538	8,633	29,803	13,102	61,145	28.4	32.8	115.5
Siasta.....	389,218	45,938	313,431	25,886	135,601	152,257	29,846	11.8	80.5	682.3
Sierra.....	84,220	22,380	56,100	6,833	16,730	32,537	5,730	26.6	66.6	230.6
Siskiyou.....	435,876	85,988	220,028	35,234	64,680	120,111	149,860	18.7	48.3	255.9
Solano.....	474,866	127,041	243,700	106,281	36,764	100,655	104,125	26.8	51.3	191.8
Sonoma.....	744,644	128,552	467,335	81,108	290,502	48,763	386,400	17.3	62.8	363.6
Stanislaus.....	649,392	211,436	131,556	57,177	25,616	48,763	105,018	32.6	20.3	662.2
Sutter.....	385,462	90,825	189,619	74,389	9,398	136,956	131,058	49.2	49.2	206.8
Tehama.....	915,227	51,917	732,252	91,898	503,398	136,956	8,143	5.7	80.0	1,410.3
Trinity.....	91,310	6,499	76,668	5,416	47,152	24,100	283,435	7.1	84.0	1,179.8
Tulare.....	1,045,231	260,812	500,984	103,328	214,042	183,614	(^b)	25.0	47.9	1,102.1
Tuolumne.....	193,072	10,967	273,746	31,974	191,985	46,787	34,447	5.7	141.8	2,496.1
Ventura.....	550,199	155,182	360,570	18,726	166,088	175,756	151,890	28.2	65.5	2,362.4
Yolo.....	463,383	130,330	181,163	49,630	71,735	59,498	72,983	28.1	39.1	139.0
Yuba.....	249,108	31,696	141,429	37,089	57,724	16,616	72,983	13.9	56.8	407.6
Total.....	27,931,444	5,707,864	15,035,433	2,913,949	6,445,256	5,676,228	7,188,147	20.4	54.0	264.1

COLORADO.

Adams.....	363,785	72,468	188,711	30,578	6,151	151,982	102,806	19.9	51.9	260.4
Arapahoe.....	284,917	36,196	177,619	10,232	3,867	161,490	71,072	12.7	62.3	490.8
Archuleta.....	85,130	12,603	31,888	4,015	21,527	6,346	40,639	14.8	37.4	253.0
Baca.....	257,314	23,963	221,015	28,536	1,258	192,189	12,366	9.3	85.9	922.4
Bent.....	168,297	40,870	87,276	12,048	10,141	73,970	40,131	24.3	51.9	213.5
Boulder.....	190,922	78,584	45,374	6,273	10,141	28,960	66,964	41.2	23.8	57.7
Chaffee.....	37,286	10,845	10,591	2,565	4,519	3,507	15,850	29.1	28.4	97.7
Cheyenne.....	216,210	18,708	90,292	35,107	110	55,015	107,210	8.6	41.8	482.8
Clear Creek.....	16,076	1,033	14,920	1,203	13,717	.....	123	6.4	92.8	1,444.3
Conejos.....	188,650	81,416	52,562	9,893	6,551	36,118	54,672	43.2	27.9	64.6
Costilla.....	159,366	20,343	20,096	2,632	13,472	3,992	118,927	12.8	12.6	98.8
Custer.....	90,799	21,402	49,992	7,957	4,648	35,549	19,315	23.6	55.1	233.6
Delta.....	142,193	51,910	25,461	4,630	5,615	14,886	64,822	36.5	17.9	49.0
Denver.....	2,763	1,388	296	210	15	71	1,079	50.2	10.7	21.3
Dolores.....	5,378	806	2,078	54	514	1,510	2,034	14.1	37.3	257.8
Douglas.....	342,018	35,235	245,938	10,495	33,239	202,204	60,845	10.3	71.9	608.0
Eagle.....	62,899	20,855	21,836	3,557	3,271	15,008	20,208	33.2	34.7	104.7
Elbert.....	682,281	71,445	525,185	25,072	23,475	249,632	85,651	10.5	77.0	735.1
El Paso.....	728,445	76,168	538,548	111,302	89,271	337,975	93,729	10.5	76.7	733.3
Fremont.....	146,866	17,808	98,114	16,854	28,658	52,692	30,944	12.1	66.8	551.0
Garfield.....	156,720	41,162	40,454	6,709	9,174	24,571	75,104	26.3	25.8	98.3
Gilpin.....	13,323	1,679	7,929	1,129	4,698	2,102	3,715	12.6	59.5	472.3
Grand.....	113,287	23,678	69,218	6,724	12,520	49,974	20,391	20.9	61.1	292.3
Gunnison.....	83,282	32,332	22,768	5,191	4,212	13,365	28,182	38.8	27.3	70.4
Hinsdale.....	5,436	1,552	1,690	304	659	727	2,194	28.6	31.1	108.9
Huerfano.....	161,834	18,882	93,002	14,658	11,885	66,493	49,650	11.7	57.5	492.5
Jackson.....	200,278	65,497	130,621	6,435	.....	123,301	4,160	32.7	65.2	199.4

b See table of counties reporting an excessive acreage in pasture, on page 13.

a Estimated.

CONNECTICUT.

Fairfield.....	267,561	88,243	88,387	26,275	26,944	35,168	90,931	33,0	33,0	100,2
Hartford.....	328,218	101,818	109,439	26,835	51,506	31,098	116,961	31,0	33,3	107,5
Litchfield.....	438,339	108,800	149,369	36,263	58,128	54,976	180,170	24,8	34,1	137,3
Middlesex.....	139,625	33,649	56,148	8,755	31,973	12,420	59,828	22,5	37,5	166,9
New Haven.....	248,049	73,761	88,010	14,611	45,844	27,585	81,248	30,5	35,5	116,2
New London.....	318,371	69,912	133,632	32,810	66,863	53,959	81,827	22,0	48,3	219,8
Tolland.....	194,248	82,020	104,813	40,813	42,513	28,092	69,910	21,8	42,2	193,8
Windham.....	241,377	51,908	89,118	16,666	30,278	22,174	100,351	21,5	36,9	171,7
Total.....	2,185,788	572,409	816,153	173,030	377,051	266,072	797,226	26,2	37,3	142,6

DELAWARE.

Kent.....	335,265	165,897	37,129	27,123	3,568	6,438	132,239	49,5	11,1	22,4
Newcastle.....	234,423	118,666	36,158	22,607	5,584	7,967	79,599	50,6	15,4	30,5
Sussex.....	469,178	189,940	30,392	17,733	6,323	6,336	248,846	40,5	6,5	16,0
Total.....	1,038,866	474,503	103,679	67,463	15,475	20,741	460,684	45,7	10,0	21,9

DISTRICT OF COLUMBIA.

District of Columbia.....	6,063	3,048	1,241	1,100	129	12	1,774	50,3	20,5	40,7
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FLORIDA.

Alachua.....	274,830	90,821	50,152	8,967	40,394	791	133,857	33,0	18,2	55,2
Baker.....	39,511	13,644	39,535		345	190	25,332	34,5	1,4	3,9
Bradford.....	131,884	48,184	14,574	363	13,085	1,126	72,126	35,7	10,8	30,2
Brevard.....	23,554	4,814	4,415	6	409	.....	20,325	18,8	1,6	8,6
Calhoun.....	82,103	15,900	4,039	279	3,742	18	62,164	19,4	4,9	25,4
Citrus.....	23,127	3,528	8,713	53	8,148	512	10,856	15,3	37,8	247,8
Clay.....	31,872	4,365	1,732	136	1,597	.....	25,775	13,5	5,6	41,6
Columbia.....	216,889	72,171	9,394	4,977	4,072	315	133,324	33,3	4,3	13,0
Dade.....	42,467	10,621	639	205	442	12	31,187	25,0	1,6	6,2
De Soto.....	156,010	16,877	65,335	15	9,537	55,763	73,798	10,8	41,9	387,1
Duval.....	110,901	6,463	36,141	80	35,656	405	68,297	58,3	32,6	339,2
Eseambia.....	70,825	13,047	2,802	105	2,327	370	54,976	18,4	4,0	21,5
Franklin.....	12,197	169	.....	.....	.....	.....	12,028	1,4	.....	.....
Godsden.....	217,443	59,168	18,865	3,976	14,281	608	136,410	27,2	8,7	31,9

^a See table of counties reporting an excessive acreage in pasture, on p. 13.

^b Estimated.

TABLE II.—*Pasture land on farms in the United States, by counties (1910 census)*—Continued.

County.	Total land in farms.	Land in crops.	Pasture land.				All other farm land.	Percentage of total farm land devoted to—		Acres in pasture per 100 acres in crops.
			Pasture land.			Other.		Crops.	Pasture.	
			Total.	Improved.	Woodland.					

FLORIDA—Continued.										
Hamilton.....	164,709	52,611	20,868	1,885	17,965	1,018	91,280	31.9	12.7	39.9
Hernando.....	25,562	6,112	2,498	314	2,058	126	16,952	23.9	9.8	40.9
Hillsborough.....	113,987	8,110	298	288	6,904	938	83,937	19.2	7.1	57.0
Holmes.....	130,966	37,203	11,911	1,365	10,460	86	81,852	28.4	9.1	32.0
Jackson.....	147,464	13,967	2,290	2,290	10,546	1,131	214,172	39.3	3.7	9.5
Jefferson.....	105,125	87,760	21,552	1,845	17,231	2,476	55,813	53.1	13.1	24.6
Lafayette.....	102,087	21,723	2,466	741	1,725	.....	77,898	21.3	2.4	11.4
Lake.....	112,124	17,179	13,996	177	13,207	612	80,949	15.3	12.5	81.5
Lee.....	54,103	7,340	8,519	.....	8,519	.....	38,244	13.6	15.7	116.0
Leon.....	197,284	69,498	30,215	4,182	21,336	4,697	97,571	35.2	22.8	64.7
Levy.....	135,514	23,737	14,773	1,985	12,452	336	97,004	17.5	10.9	62.2
Liberty.....	63,156	8,942	17,470	50	17,420	.....	36,744	14.1	27.7	195.4
Madison.....	251,495	83,241	12,668	7,229	4,688	751	153,586	33.1	5.0	15.2
Manatee.....	62,448	12,512	10,208	433	8,357	1,418	39,728	20.0	16.3	81.6
Marion.....	218,551	66,670	27,265	3,047	23,330	888	124,616	30.5	12.5	40.9
Monroe.....	4,720	955	.....	.....	.....	.....	3,765	20.2	.....	.....
Nassau.....	121,573	5,258	6,428	7	6,421	.....	109,887	43.2	5.3	122.3
Orange.....	122,533	18,213	1,684	166	1,518	.....	102,636	14.9	1.4	9.2
Osceola.....	92,704	3,500	20,614	241	13,071	7,302	68,590	37.8	22.2	589.0
Palm Beach.....	18,468	4,752	101	13	88	.....	13,615	25.7	5	2.1
Pasco.....	48,596	7,318	2,265	395	1,630	220	39,013	15.1	4.7	31.0
Polk.....	183,730	18,094	52,966	144	45,670	7,152	112,670	16.8	28.8	292.7
Putnam.....	76,843	12,948	10,672	97	9,858	717	53,223	11.5	13.9	82.4
Saint John.....	49,339	9,582	1,101	16	839	246	38,656	19.4	22.3	11.5
Saint Lucie.....	18,219	3,638	59	2	57	.....	14,522	20.0	3	1.6
Santa Rosa.....	99,425	17,411	2,615	56	2,559	.....	79,399	17.5	2.6	15.0
Sumter.....	76,519	15,879	21,107	593	2,514	18,000	39,533	20.8	27.6	132.9
Suwanee.....	273,330	87,549	6,927	3,679	2,948	300	178,854	32.0	2.5	7.9
Taylor.....	65,043	15,719	1,039	152	848	39	48,285	24.2	1.6	6.6
Volusia.....	72,975	10,578	4,421	114	4,307	.....	57,976	14.5	6.1	41.8
Wakulla.....	63,642	10,346	4,902	125	4,469	.....	48,304	16.3	7.8	48.3
Walton.....	113,024	25,972	10,224	85	2,574	398	76,828	23.4	9.0	39.4
Washington.....	141,578	29,144	1,585	117	1,121	7,565	110,839	20.6	1.1	5.5
Total.....	5,253,538	1,320,450	578,712	51,034	410,765	116,943	3,354,346	25.1	11.0	43.8

	280,985	45,030	30,922	114	29,670	1,138	205,033	16.0	11.0	68.7
Appling.....	129,894	52,003	13,314	534	12,682	118	70,891	42.3	8.9	23.6
Baker.....	119,533	56,569	16,854	1,960	10,570	4,424	70,590	37.9	18.1	31.6
Baldwin.....	129,800	48,980	14,999	3,113	10,439	1,447	63,956	40.2	6.8	16.9
Banks.....	220,842	88,838	29,093	87	28,121	885	117,005	24.9	22.4	89.9
Bartow.....	307,807	78,918	59,261	1,358	56,709	1,947	229,628	21.5	16.1	73.1
Berrien.....	125,832	106,809	21,166	1,926	8,689	1,285	68,529	44.8	8.4	18.7
Bibb.....	282,106	125,320	10,516	1,572	18,000	640	58,966	37.9	7.5	19.8
Brooks.....	152,204	15,836	10,018	1,204	9,494	350	131,131	10.4	6.6	63.4
Bryan.....	425,502	121,959	47,709	1,605	45,481	623	126,320	28.7	11.2	39.1
Bulloch.....	185,636	67,897	6,307	526	6,267	44	255,834	52.3	1.9	3.7
Burke.....	107,937	62,362	13,214	2,638	9,378	1,198	162,239	28.7	12.2	21.2
Butts.....	111,397	63,554	5,532	2	5,528	2	42,311	57.1	5.0	8.7
Calhoun.....	8,460	34,068	11,931	1,931	30,722	1,415	132,851	4.3	17.4	402.7
Candler.....	115,648	41,070	13,896	3,259	8,382	1,755	58,182	38.1	11.6	30.4
Campbell.....	123,413	31,111	6,560	6,560	21,820	2,715	134,914	42.6	10.8	25.2
Carroll.....	22,647	6,066	3,543	3,543	2,132	371	58,971	26.0	7.0	26.8
Catoosa.....	86,984	6,811	4,043	3	4,022	18	105,754	5.8	3.5	59.4
Charlton.....	49,250	7,063	7,165	2,789	3,881	495	66,022	14.3	14.5	101.4
Chatham.....	118,814	35,430	14,061	1,049	12,452	560	69,323	29.8	11.8	39.7
Chatahoochee.....	154,962	50,410	19,381	6,821	9,015	3,545	84,871	32.6	12.5	38.4
Chattooga.....	209,823	52,973	29,969	2,757	22,874	4,338	126,881	25.2	14.3	56.6
Cherokee.....	67,152	40,041	8,635	1,244	6,522	869	18,476	59.6	12.9	21.6
Clarke.....	100,068	56,347	7,122	704	5,748	670	42,599	53.1	6.7	12.6
Clay.....	87,658	41,633	8,094	830	6,333	931	37,931	47.5	9.2	19.4
Clayton.....	226,212	17,447	90,323	1,061	89,262	7.7	118,442	7.7	38.9	517.7
Clinch.....	194,319	80,640	32,115	6,385	22,770	3,010	81,514	41.5	16.6	39.9
Cobb.....	417,972	71,825	12,333	8	12,072	253	333,104	17.2	3.0	17.2
Coffee.....	244,679	68,613	1,949	75	1,360	514	174,117	28.0	8.8	2.9
Colquitt.....	193,690	66,401	11,737	1,134	9,297	1,306	58,352	48.7	8.6	17.6
Columbia.....	243,935	125,951	19,458	3,295	13,510	2,653	98,526	51.6	8.0	15.4
Coweta.....	163,568	52,242	17,637	2,207	13,829	1,601	63,689	31.9	10.8	33.8
Crawford.....	132,616	67,194	3,233	2,518	2,475	240	62,189	50.7	2.4	4.8
Crisp.....	61,063	12,737	4,665	2,834	1,378	433	43,661	20.3	7.6	36.6
Dade.....	98,345	19,981	11,803	1,412	7,485	2,906	66,561	20.9	2.0	39.1
Dawson.....	399,874	103,022	16,098	1,249	13,284	1,565	280,754	25.8	4.0	15.6
Decatur.....	143,241	58,966	24,801	4,283	17,637	2,881	59,474	41.2	17.3	42.0
DeKalb.....	246,424	113,343	19,863	14	18,849	1,007	113,218	46.0	8.1	17.5
Dodge.....	206,636	127,606	13,830	1,294	11,489	1,067	65,480	61.7	6.7	10.9
Dooly.....	134,235	62,095	5,534	473	8,826	235	66,006	46.3	4.1	8.9
Douglas.....	107,131	37,349	12,294	1,511	9,781	1,002	57,491	34.9	11.5	32.9
Early.....	191,327	100,575	2,580	1,763	3,919	268	84,672	52.6	3.2	6.0
Echols.....	121,936	11,572	2,630	760	1,770	25	107,831	9.5	2.1	21.9
Effingham.....	217,487	26,658	1,613	22	1,566	25	189,216	12.2	7.7	6.1
Elbert.....	199,366	84,559	20,337	2,719	13,717	1,901	94,470	42.4	10.2	24.1
Emmett.....	385,234	130,438	50,934	1,710	49,179	45	203,862	33.9	13.2	39.1
Fannin.....	187,729	25,787	16,898	3,714	12,055	1,129	145,044	13.7	9.0	65.5

TABLE II.—*Pasture land on farms in the United States, by counties (1910 census)*—Continued.

County.	Total land in farms.	Land in crops.	Pasture land.				All other farm land.	Percentage of total farm land devoted to—		Acres in pasture per 100 acres in crops.
			Total.		Woodland.			Crops.	Pasture.	
			Improved.	Other.						
Fayette.....	111,998	54,481	14,729	2,782	6,965	4,982	42,788	48.6	13.2	27.0
Flord.....	252,146	85,062	34,837	4,995	28,737	1,105	132,247	33.7	13.8	41.0
Forsyth.....	146,484	54,427	18,608	2,788	11,366	4,454	73,449	37.2	12.7	34.2
Franklin.....	147,629	75,100	21,460	2,687	14,125	4,648	51,069	50.9	14.5	28.6
Fulton.....	59,419	17,103	6,210	528	5,227	528	36,106	28.8	10.5	36.3
Gilmer.....	197,139	24,379	21,433	3,316	17,546	571	151,327	12.4	10.9	87.9
Glasscock.....	66,529	32,337	7,813	1,180	2,648	3,985	26,379	48.6	11.7	24.2
Glynn.....	62,782	3,151	1,996	72	1,725	199	57,635	5.0	31.8	63.3
Gordon.....	195,253	62,094	23,288	6,639	14,854	1,795	112,871	31.3	11.7	37.5
Grady.....	232,545	74,875	8,184	430	7,522	2,232	149,486	32.2	3.5	10.9
Greene.....	202,225	83,364	26,791	5,834	17,867	3,090	92,070	41.2	13.3	32.1
Gwinnett.....	283,548	114,564	37,776	5,621	25,126	7,029	133,208	40.1	13.2	33.0
Habersham.....	131,426	25,757	18,743	1,581	15,771	1,391	86,926	19.6	14.3	72.8
Hall.....	240,455	72,051	26,543	5,274	17,826	3,443	141,861	30.0	11.0	36.8
Hancock.....	253,508	115,107	35,213	6,757	23,490	4,966	103,188	45.4	13.9	30.6
Haralson.....	148,852	45,214	29,849	4,944	18,062	6,843	73,789	30.4	20.0	66.0
Harris.....	244,564	97,406	20,866	4,107	13,163	3,596	126,292	39.8	8.5	21.4
Hart.....	147,355	75,436	16,453	3,314	9,883	3,256	55,466	51.2	11.2	21.8
Hart.....	161,812	63,563	21,863	6,084	13,546	2,233	76,386	39.3	13.5	34.4
Heard.....	192,009	101,412	16,353	2,683	13,803	1,867	74,244	52.9	8.5	16.1
Henry.....	290,578	176,648	18,201	2,364	9,909	2,270	99,387	60.8	5.0	8.2
Houston.....	188,394	43,560	29,422	1,099	10,627	6,475	126,643	23.1	9.7	41.8
Irwin.....	255,701	136,695	29,422	4,689	20,016	4,737	89,584	53.5	11.5	21.5
Jasper.....	179,815	94,975	14,432	2,167	11,670	595	70,408	52.8	8.0	15.2
Jeff Davis.....	160,809	19,111	3,184	129	2,616	439	138,514	11.9	2.0	16.7
Jefferson.....	261,469	138,298	25,221	2,964	21,112	1,145	97,950	52.9	9.6	18.2
Jenkins.....	162,319	60,816	7,762	87	1,443	26	99,947	37.5	1.0	2.6
Johnson.....	144,193	74,796	7,762	187	6,406	1,159	61,635	51.9	5.0	10.4
Jones.....	216,153	84,345	26,918	4,535	20,529	1,854	104,890	39.0	12.5	31.9
Laurens.....	410,774	189,092	13,084	1,545	9,086	2,453	208,598	46.0	3.2	6.9
Lee.....	188,627	99,766	8,550	1,116	5,551	1,883	75,311	54.3	4.7	8.6
Liberty.....	231,528	28,452	99,776	7,366	98,879	531	103,301	12.3	43.1	350.7
Lincoln.....	134,056	43,879	14,056	2,492	9,622	1,942	74,063	34.1	10.4	30.6
Lowndes.....	284,224	72,111	15,229	1,113	15,968	1,148	193,884	25.4	6.4	25.3
Lumpkin.....	99,249	16,382	7,519	318	6,119	1,082	75,348	16.5	7.6	45.9
McDuffie.....	117,302	49,469	8,236	81	8,137	18	59,597	42.2	7.0	16.6

GEORGIA—Continued.

	31,540	2,885	9,564	436	6,216	2,912	19,091	9.1	30.3	331.5
McIntosh.....	198,655	105,615	19,277	1,305	16,210	1,762	73,763	53.2	9.7	18.3
Macon.....	156,423	78,714	19,795	2,088	16,529	1,178	57,914	50.3	12.7	25.1
Madison.....	186,483	65,095	11,466	1,870	5,801	3,795	109,922	34.0	6.1	17.6
Marion.....	265,266	143,297	23,060	2,662	18,301	2,097	98,939	54.0	8.7	16.1
Meriwether.....	109,020	33,432	3,732	250	6,372	1,094	71,846	30.7	3.4	11.2
Miller.....	32,600	11,023	2,697	2,697	6,632	1,220	38,020	39.9	13.5	33.8
Milton.....	278,193	121,761	10,823	994	9,479	350	145,609	43.8	3.9	8.9
Mitchell.....	264,460	106,438	45,277	8,850	26,960	9,467	112,745	40.2	17.1	42.6
Monroe.....	298,197	198,822	3,006	177	1,720	1,149	196,339	33.1	1.0	3.0
Monroeville.....	16,645	107,171	3,006	2,380	13,116	1,149	58,439	58.8	9.1	15.5
Morgan.....	182,253	31,561	12,408	4,181	7,053	1,174	112,201	20.2	7.0	39.3
Murray.....	106,954	36,441	17,737	2,592	12,957	2,188	52,776	34.1	16.6	48.4
Muskegon.....	132,216	83,201	10,154	1,530	7,391	1,233	58,861	34.7	6.7	12.2
Newton.....	104,879	58,597	9,548	1,780	6,584	1,184	36,734	55.9	9.1	16.3
Oconee.....	100,712	31,290	4,203	23,811	23,811	3,266	96,339	44.1	13.7	31.1
Oglethorpe.....	168,396	55,258	24,774	4,506	15,780	4,488	88,364	32.8	14.7	44.8
Paulding.....	119,940	23,199	12,826	1,238	6,346	5,242	83,915	19.3	10.7	55.3
Pickens.....	233,756	34,963	20,192	2,612	17,347	233	178,601	15.0	8.6	57.7
Pike.....	179,215	97,712	17,807	1,721	13,449	2,037	63,696	54.5	9.9	18.2
Polk.....	153,812	58,622	19,144	3,419	15,273	452	76,046	38.1	12.4	32.7
Pulaski.....	131,282	67,301	7,168	667	5,988	513	96,795	55.8	3.0	5.5
Putnam.....	177,852	67,301	16,918	2,288	11,468	3,162	93,633	37.8	9.5	25.1
Rabun.....	183,293	31,988	4,942	2,140	1,714	3,088	46,365	38.4	5.9	15.4
Randolph.....	118,478	13,413	21,053	2,062	17,156	1,835	84,010	11.3	17.8	156.9
Randolph.....	228,588	107,209	11,959	2,649	7,708	1,002	109,420	46.9	5.2	11.2
Richmond.....	144,724	53,529	6,546	1,100	4,289	1,137	84,649	37.0	4.5	12.2
Rockdale.....	73,749	34,541	7,583	1,277	5,553	723	31,625	46.8	10.3	22.0
Schley.....	98,487	41,922	10,448	1,335	8,061	1,052	46,117	42.6	10.6	24.9
Screven.....	324,713	105,603	38,980	336	38,531	113	180,130	35.1	12.0	36.9
Spalding.....	117,003	64,488	12,700	2,659	8,251	1,790	39,815	55.1	10.9	19.7
Stephens.....	92,521	24,876	13,005	995	11,675	965	54,040	20.9	14.7	54.7
Stewart.....	214,502	88,066	3,947	3,947	11,341	8,572	102,576	41.1	11.1	27.1
Sumter.....	276,834	160,587	9,325	1,080	6,324	2,121	106,722	58.0	3.4	5.9
Talbot.....	63,942	34,931	5,212	5,212	26,154	3,565	81,816	35.4	19.3	54.6
Taliaferro.....	43,332	a 5,695	a 5,695	a 5,695	a 4,936	a 1,72	51,993	42.9	5.6	13.1
Tattall.....	72,439	72,439	772	643	85	44	232,687	22.2	6.2	1.1
Taylor.....	68,018	11,068	11,068	2,589	8,317	562	127,673	32.5	5.6	17.2
Telfair.....	58,369	4,878	4,878	141	4,274	403	144,023	28.2	4.4	8.4
Terrell.....	118,262	7,183	7,183	513	4,234	2,436	52,362	66.5	2.0	6.1
Thomas.....	255,654	97,116	11,764	2,765	8,848	151	146,774	38.0	4.6	12.1
Tift.....	113,434	37,714	3,897	69	2,743	1,085	71,823	33.3	3.4	10.3
Toombs.....	49,976	1,124	1,124	3,342	179	945	124,218	28.5	6	2.2
Towns.....	65,969	12,343	7,672	3,452	3,452	878	45,954	18.7	11.6	62.2
Troup.....	220,330	103,632	26,481	3,609	17,929	4,943	90,217	47.0	12.0	25.6
Turner.....	130,089	49,837	6,416	75	4,372	69	75,716	38.3	3.5	9.1
Twiggs.....	172,312	72,561	12,776	743	6,078	5,955	86,975	42.1	17.6	17.6
Union.....	142,497	25,322	19,041	4,257	10,749	4,935	98,134	17.8	13.4	75.2
Upson.....	170,188	68,572	25,642	5,523	17,718	2,102	75,973	40.3	15.1	37.4

a Estimated.

TABLE II.—*Pasture land on farms in the United States, by counties (1910 census)*—Continued.

County.	Total land in farms.	Land in crops.	Pasture land.			All other farm land.	Percentage of total farm land devoted to—		Acres in pasture per 100 acres in crops.	
			Total.	Improved.	Woodland.		Other.	Crops.		Pasture.
GEORGIA—Continued.										
Walker.....	214,793	50,232	18,272	11,248	6,454	570	146,289	23.4	8.5	36.4
Walton.....	200,609	109,706	20,379	1,723	13,923	5,133	70,524	54.7	10.2	18.6
Ware.....	164,729	21,393	17,253	15	17,133	1,055	126,083	13.0	10.7	80.7
Warren.....	158,264	78,743	26,349	1,967	18,666	3,710	53,172	49.7	16.6	33.5
Washington.....	341,952	182,179	27,327	1,668	22,563	3,096	132,446	53.3	8.0	15.0
Wayne.....	319,799	32,938	44,341	25	44,314	1,908	242,520	10.3	13.9	134.6
Webster.....	107,359	50,805	9,364	1,288	6,168	1,682	47,190	47.3	8.7	18.4
White.....	107,591	19,712	11,314	1,887	8,745	1,302	76,565	18.3	10.5	57.4
Whitfield.....	162,383	42,840	21,808	6,957	13,549	2,222	97,735	26.4	13.4	50.9
Wilcox.....	188,315	73,373	6,655	.....	6,633	3,867	108,287	39.0	3.5	9.1
Wilkes.....	255,512	115,591	34,338	2,227	28,244	3,867	105,583	45.2	13.4	29.7
Wilkinson.....	219,172	68,383	7,232	2,093	3,656	1,483	143,557	31.2	3.3	10.6
Worth.....	203,147	95,742	1,293	100	1,142	51	106,112	47.1	.6	1.4
Total.....	26,933,413	9,860,904	2,537,399	313,305	1,956,233	267,861	14,555,050	36.5	9.4	25.6
HAWAII.										
Hawaii.....	1,496,061	99,017	783,843	3,794	283,711	496,338	613,201	6.6	52.4	791.6
Honolulu.....	256,621	41,902	129,958	28,156	40,602	61,240	84,721	16.3	50.7	310.3
Kalawao.....	6,464	12	6,400	.....	.....	6,400	52	.2	99.0	53,333.3
Kanai.....	309,014	38,734	142,684	6,809	101,125	34,750	127,596	12.5	46.2	368.4
Maui.....	522,440	37,267	331,092	8,155	66,847	236,040	151,081	7.1	63.4	888.4
Total.....	2,590,600	216,932	1,394,017	46,914	492,285	854,818	979,651	8.4	53.8	642.6

IDAHO.

Ada.....	136,067	48,486	27,465	14,399	4,083	8,083	60,116	35.6	20.2	56.6
Bannock.....	307,403	91,075	87,342	18,993	5,007	63,348	128,986	28.4	28.4	95.9
Bear Lake.....	167,276	63,147	59,519	24,256	2,571	32,692	131,010	37.8	33.6	94.3
Bingham.....	303,704	127,085	21,105	6,781	3,643	11,900	157,314	6.9	21.1	76.6
Blaine.....	210,255	57,989	74,427	14,279	15,069	32,982	107,839	27.6	46.1	219.9
Boise.....	170,252	55,731	78,567	32,982	15,069	30,576	55,984	21.0	16.5	158.9
Bonner.....	183,082	19,053	30,280	2,474	7,797	4,278	133,749	10.4	17.5	62.8
Canyon.....	272,164	75,891	47,685	11,397	7,797	28,491	148,588	20.9	15.2	81.2
Cassia.....	166,768	31,142	25,275	10,278	6,642	14,355	110,351	18.7	30.4	95.3
Custer.....	73,556	23,464	22,361	10,734	2,104	9,523	27,731	31.9	9.5	40.8
Elmore.....	78,880	18,342	7,479	989	1,817	4,673	53,059	23.3	16.4	130.3
Fremont.....	526,236	216,169	86,404	26,172	15,287	44,945	223,663	41.1	40.6	130.3
Idaho.....	418,831	130,496	170,084	19,467	46,972	103,645	118,251	31.2	32.0	131.1
Kootenai.....	228,807	55,769	73,140	9,591	59,029	16,969	98,205	29.7	29.7	71.8
Latah.....	340,432	140,953	101,274	10,410	73,865	18,674	38,759	28.1	32.6	116.1
Lemhi.....	98,736	27,337	32,224	8,015	5,535	18,674	38,759	28.1	32.6	116.1
Lincoln.....	164,147	57,347	24,780	5,999	3,283	15,508	102,011	22.7	13.1	66.4
Noz Perce.....	573,050	214,950	187,760	11,721	82,502	93,127	172,350	37.4	32.6	58.7
Oneida.....	382,045	112,467	66,010	19,573	3,858	42,639	203,488	29.4	17.3	58.7
Owyhee.....	71,528	20,734	6,545	2,405	1,060	3,080	41,229	29.0	9.2	31.5
Shoshone.....	13,962	1,976	3,052	65	2,000	1,368	8,934	14.2	21.9	154.5
Twin Falls.....	150,385	75,925	5,020	3,083	567	1,368	69,440	50.5	3.3	6.6
Washington.....	242,008	65,527	64,727	11,483	10,412	42,832	111,754	27.1	26.7	98.8
Total.....	5,283,604	1,691,491	1,272,604	271,348	375,418	625,838	2,319,509	32.0	24.1	75.2

ILLINOIS.

Adams.....	495,864	268,478	150,227	63,468	70,272	16,457	77,159	54.1	30.3	56.0
Alexander.....	82,896	35,656	8,358	1,848	6,063	16,447	38,882	43.0	10.0	23.4
Bond.....	223,286	124,737	61,094	32,311	21,963	6,820	37,455	55.9	27.4	49.0
Boone.....	172,312	106,917	51,434	21,632	10,305	19,497	13,961	62.0	29.8	48.1
Brown.....	181,939	85,401	68,868	21,891	37,743	9,234	27,670	46.9	37.8	80.6
Bureau.....	524,455	855,784	138,954	77,955	45,370	15,629	29,717	67.8	26.5	39.1
Calhoun.....	112,098	157,337	37,000	8,112	26,628	2,235	47,761	40.4	26.0	64.5
Carroll.....	272,814	162,740	92,997	48,926	23,001	21,070	17,077	59.6	34.1	57.1
Cass.....	207,007	125,084	50,162	19,347	21,553	9,262	31,761	60.4	24.2	40.1
Champaign.....	608,428	497,983	73,898	64,654	12,231	7,113	36,547	81.8	12.1	26.7
Christian.....	422,520	310,951	83,054	62,244	16,700	4,110	28,515	73.6	19.7	23.8
Clark.....	301,318	152,605	89,888	53,387	25,522	10,979	58,825	50.6	25.6	58.9
Clay.....	266,489	129,651	68,350	47,401	16,729	4,220	68,488	48.0	29.8	52.7
Clinton.....	280,440	180,325	42,873	28,001	12,191	2,681	20,547	64.3	15.3	23.8
Coles.....	306,098	216,460	68,791	42,106	23,242	3,443	20,242	70.7	22.5	31.8
Cook.....	387,603	292,049	77,005	30,621	27,525	18,859	48,549	67.6	19.9	29.4
Crawford.....	238,143	112,271	61,672	46,570	12,196	2,906	64,200	47.1	25.9	55.0
Cumberland.....	205,725	120,685	47,537	30,378	15,292	1,867	37,593	58.9	23.1	39.4

TABLE II.—*Pasture land on farms in the United States, by counties (1910 census)*—Continued.

County.	Total land in farms.	Land in crops.	Pasture land.				All other farm land.	Percentage of total farm land de- voted to—		Acres in pasture per 100 acres in crops.
			Total.	Improved.	Woodland.	Other.		Crops.	Pasture.	
ILLINOIS—Continued.										
DeKalb.....	388,838	287,844	84,059	55,784	11,822	16,453	16,955	74.0	21.6	29.2
Dewitt.....	243,991	185,133	50,037	27,923	19,625	2,489	8,821	75.9	20.5	27.0
Douglas.....	256,478	200,981	42,023	29,167	10,590	2,266	13,474	78.4	16.4	20.9
DuPage.....	178,600	117,185	44,946	22,440	12,148	5,209	16,469	65.6	25.2	38.4
Edgar.....	381,150	268,132	84,365	54,943	24,213	5,358	28,653	70.3	22.1	31.5
Edwards.....	147,184	77,320	34,614	24,972	8,228	1,414	35,230	52.5	23.5	44.8
Efingham.....	281,310	154,008	67,853	36,224	27,254	4,375	59,419	54.7	24.1	44.1
Fayette.....	417,832	224,304	103,341	57,398	40,442	5,501	90,187	53.7	24.7	46.0
Ford.....	304,019	255,690	40,021	33,020	11,294	4,667	8,308	84.1	13.2	15.6
Franklin.....	222,578	104,705	50,500	37,875	11,331	1,331	67,373	47.0	22.7	48.2
Fulton.....	506,222	280,075	139,547	39,657	90,616	29,274	66,600	55.3	31.5	57.0
Gallatin.....	162,693	97,976	25,212	14,483	9,007	1,722	39,505	60.2	13.5	23.7
Greene.....	308,579	156,935	106,754	50,892	46,271	9,591	44,890	50.9	34.6	68.0
Grundy.....	249,984	194,957	41,850	23,687	13,223	4,940	13,177	78.0	16.7	21.5
Hamilton.....	247,996	127,619	65,749	45,477	13,342	6,930	54,628	51.5	26.5	51.5
Hancock.....	479,919	279,867	146,359	73,885	58,691	13,783	53,693	58.3	30.5	52.3
Hardin.....	102,617	29,946	31,911	18,313	12,519	1,079	40,710	29.2	31.1	106.3
Henderson.....	209,367	121,592	65,887	29,470	28,722	7,695	21,888	58.1	31.5	54.2
Henry.....	504,927	326,930	139,354	91,961	22,675	24,718	38,643	64.8	27.6	42.6
Iroquois.....	679,335	544,936	105,159	71,391	27,947	5,821	29,220	80.2	15.5	19.3
Jackson.....	305,739	143,104	53,969	18,748	30,179	5,042	108,686	46.8	17.6	37.7
Jasper.....	290,375	161,685	61,497	48,142	12,292	1,063	67,193	55.7	21.2	38.0
Jefferson.....	336,340	161,255	93,344	66,001	18,391	8,952	81,741	47.9	27.7	57.9
Jersey.....	215,933	109,470	54,581	18,650	29,297	6,634	51,850	50.7	25.3	49.9
Jo Daviess.....	363,130	159,669	151,681	60,805	64,672	26,204	51,780	44.0	41.8	95.0
Johnson.....	201,438	74,704	54,768	29,173	21,456	4,139	71,966	37.1	27.2	73.3
Kane.....	309,284	194,568	90,154	38,760	29,011	22,383	24,562	62.9	29.1	46.3
Kankakee.....	402,237	294,763	76,186	49,273	18,517	8,396	31,288	73.3	18.9	25.8
Kendall.....	195,774	142,933	39,907	22,041	13,102	4,764	12,944	73.0	20.4	27.9
Knox.....	424,381	264,157	126,769	55,350	53,279	18,140	33,455	62.2	29.9	48.0
Lake.....	251,003	131,760	83,673	38,063	33,894	21,716	35,570	52.5	33.3	63.5
La Salle.....	662,755	485,905	70,247	45,921	14,670	46,012	46,012	73.3	19.7	26.9
Lawrence.....	201,865	105,773	43,507	33,446	8,444	1,617	52,583	52.4	21.6	41.1
Lee.....	443,814	311,108	104,077	60,131	14,942	29,004	28,629	70.1	23.4	33.4
Livingston.....	646,551	546,210	66,999	50,801	12,053	4,145	33,342	84.5	10.4	12.3
Logan.....	381,478	303,859	66,999	38,279	14,895	2,296	22,419	79.7	14.5	18.2
McDonough.....	333,776	226,771	89,946	43,672	35,311	10,763	37,059	64.1	25.4	39.7

McHenry.....	368,931	200,791	121,189	34,856	39,148	47,185	46,951	54.4	32.8	60.4
McLean.....	733,161	571,372	113,620	86,499	25,866	8,315	41,969	78.0	16.3	20.9
Macon.....	356,946	280,397	61,481	41,778	13,567	4,136	11,888	78.6	17.2	21.9
Macoupin.....	511,225	301,461	136,193	62,629	77,782	13,772	53,571	68.0	30.6	51.2
Madison.....	408,487	277,698	142,111	36,840	25,655	79,616	(a)	50.5	34.8	31.3
Marion.....	335,624	169,533	86,962	55,177	27,759	4,026	79,129	68.8	25.9	36.4
Marshall.....	304,256	160,031	58,177	25,773	27,220	14,248	14,248	74.2	11.5	15.5
Mason.....	304,226	225,723	35,057	20,067	11,269	3,721	43,446	65.1	20.4	46.7
Massac.....	129,341	57,660	26,424	16,508	6,320	3,596	45,857	44.1	24.2	36.3
Menard.....	192,910	127,187	46,620	31,492	11,730	3,398	19,103	65.9	20.4	46.7
Merger.....	183,318	114,660	64,100	34,916	15,640	28,333	56.2	35.1	62.5	62.5
Monroe.....	208,790	121,548	20,694	8,745	9,633	2,316	66,548	58.2	39.1	17.0
Montgomery.....	426,398	271,982	102,218	63,802	32,548	5,867	49,198	64.3	29.1	37.2
Morgan.....	352,946	219,720	102,892	64,960	27,458	10,474	30,334	62.5	24.0	46.8
Moultrie.....	207,249	148,115	37,225	22,116	11,210	3,869	21,609	71.6	18.0	25.1
Ogle.....	462,010	324,760	105,676	43,350	27,383	29,941	31,574	70.3	22.9	32.5
Peoria.....	333,206	220,484	92,326	34,087	30,071	8,768	39,796	62.4	26.3	42.1
Perry.....	234,915	111,466	42,964	20,238	16,004	6,712	22,646	47.4	18.3	38.6
Piatt.....	274,937	215,049	28,195	83,455	56,132	13,226	73,520	51.5	32.0	62.2
Pike.....	476,810	245,477	152,813	85,455	24,637	13,226	86,468	33.0	26.2	79.4
Pope.....	69,689	69,689	55,327	25,275	24,637	5,415	86,468	33.0	15.9	31.5
Putlaski.....	101,372	51,220	16,124	6,550	8,767	807	34,028	58.1	31.0	53.3
Putnam.....	52,596	53,787	28,681	9,364	16,497	2,820	10,128	50.5	15.9	31.5
Randolph.....	323,237	169,017	43,888	19,288	21,337	3,263	110,332	52.3	13.6	26.0
Rock Island.....	217,258	111,350	43,968	31,577	8,651	3,740	61,940	51.3	20.2	39.5
Rock Island.....	237,936	128,476	78,468	29,880	31,922	16,666	30,992	68.3	33.0	61.1
Saint Clair.....	364,523	249,031	41,996	18,797	18,286	4,913	73,496	54.0	11.5	16.9
Saline.....	213,831	104,955	47,790	34,491	10,989	2,310	61,086	49.1	22.3	45.6
Sangamon.....	520,900	368,784	119,521	81,176	31,849	6,496	32,994	70.8	22.9	32.4
Schuyler.....	329,165	128,850	85,713	21,380	32,413	18,920	44,572	49.7	33.1	66.5
Scott.....	130,586	85,958	40,302	14,163	13,423	4,714	24,326	57.1	26.8	46.9
Shelby.....	461,878	295,955	103,694	60,690	35,803	4,201	62,199	64.1	22.4	35.0
Stark.....	175,919	115,717	41,448	24,827	11,104	5,517	18,554	66.8	23.6	33.8
Stephenson.....	344,921	226,912	94,889	55,794	23,569	13,526	33,120	65.8	27.5	41.8
Tazewell.....	374,528	272,879	72,486	31,732	31,732	9,673	29,163	72.9	19.4	26.6
Union.....	227,405	97,012	36,596	14,452	17,034	5,110	93,797	42.7	16.1	37.2
Vermilion.....	534,355	393,424	99,142	60,713	32,577	5,852	41,819	73.6	18.6	25.2
Wabash.....	124,079	77,668	16,493	11,276	3,356	1,891	29,918	62.6	13.3	21.2
Warren.....	326,653	217,123	95,141	43,996	36,722	14,423	14,389	66.5	16.9	43.8
Washington.....	329,635	202,534	55,729	28,071	36,722	4,328	70,872	61.5	29.0	27.5
Wayne.....	408,512	179,324	126,734	88,565	29,026	9,143	102,454	43.9	31.0	70.7
White.....	285,027	166,412	49,800	39,313	9,254	1,293	68,755	58.4	17.5	30.0
Whiteside.....	416,465	265,555	127,730	68,131	24,805	34,794	23,180	63.8	30.7	48.1
Will.....	498,651	365,136	103,681	49,829	29,887	24,565	29,834	73.2	20.8	28.4
Williamson.....	227,642	101,021	50,950	36,442	11,662	2,826	75,691	44.4	22.4	50.4
Winnebago.....	303,080	196,592	84,546	40,814	28,303	13,429	21,942	64.9	27.9	33.3
Woodford.....	316,064	230,652	76,736	28,538	40,494	7,704	8,676	73.0	24.3	33.3
Total.....	32,522,937	20,523,978	7,636,546	4,081,506	2,550,782	1,004,258	4,362,413	63.1	23.5	37.2

^a See table of counties reporting an excessive acreage in pasture, on page 13.

TABLE II.—*Pasture land on farms in the United States, by counties (1910 census)*—Continued.

County.	Total land in farms.	Land in crops.	Pasture land.				All other farm land.	Percentage of total farm land devoted to—		Acres in pasture per 100 acres in crops.
			Total.	Improved.	Woodland.	Other.		Crops.	Pasture.	
INDIANA.										
Adams.....	208,802	132,805	53,930	26,720	22,770	4,440	22,007	63.6	25.8	40.6
Allen.....	395,312	236,575	101,386	35,992	53,927	11,477	57,341	59.8	25.7	42.9
Bartholomew.....	244,900	139,113	46,577	21,651	20,270	4,656	59,210	56.8	19.0	33.5
Benton.....	252,196	208,564	35,494	27,510	3,943	4,041	8,138	52.7	14.1	17.0
Blackford.....	98,373	57,000	29,372	16,824	10,905	1,643	11,941	88.0	29.9	51.5
Boone.....	264,558	180,626	60,168	27,522	31,019	1,627	23,764	68.3	22.7	33.3
Brown.....	160,798	40,157	42,182	24,768	13,540	3,874	28,459	25.0	26.2	105.0
Carroll.....	227,630	146,172	52,778	23,349	24,565	4,864	28,680	64.2	23.2	36.1
Cass.....	249,838	151,401	61,334	26,579	27,756	6,999	37,103	60.6	24.5	40.5
Clark.....	216,868	79,130	47,487	23,731	20,310	3,446	90,251	36.5	21.9	60.0
Clay.....	212,461	104,484	56,209	24,695	26,978	4,536	51,768	49.2	24.5	53.8
Clinton.....	253,853	183,802	58,711	30,689	20,609	2,833	16,340	72.4	21.2	29.2
Crawford.....	181,483	56,859	54,744	16,100	24,640	13,944	69,880	31.3	30.2	96.3
Daviess.....	253,412	133,938	57,620	43,412	11,511	2,697	61,854	52.9	22.7	43.0
Dearborn.....	185,405	81,227	55,586	21,271	15,960	18,355	48,592	43.8	30.0	68.4
Decatur.....	223,171	123,912	67,081	34,572	22,189	10,320	32,178	55.5	30.1	54.1
Delaware.....	221,903	124,957	59,702	23,529	31,003	5,170	37,244	56.3	26.9	47.8
Dubois.....	240,453	146,253	68,742	40,636	24,822	3,284	25,488	60.8	28.6	47.0
Dubois.....	262,576	104,661	67,007	24,428	26,740	15,839	90,908	39.9	25.5	64.0
Elkhart.....	170,530	153,035	53,346	17,427	25,322	10,507	64,149	56.6	19.7	34.9
Fayette.....	80,759	69,187	36,006	16,100	15,893	4,043	29,007	51.6	26.8	52.0
Floyd.....	207,845	30,719	6,439	6,439	6,298	2,125	35,178	38.0	18.4	48.4
Fountain.....	240,732	149,762	63,602	27,843	30,377	5,382	27,431	62.2	26.4	42.5
Franklin.....	240,732	92,896	80,487	32,405	29,224	18,848	67,349	38.6	33.4	86.6
Fulton.....	221,387	115,899	55,623	28,050	18,735	8,838	49,865	52.4	25.1	48.0
Gibson.....	273,102	166,879	47,230	29,645	14,386	3,199	58,983	61.1	17.3	28.3
Grant.....	246,857	149,850	67,243	37,069	26,175	3,999	79,764	60.7	27.2	44.9
Greene.....	315,073	127,441	104,414	65,257	25,531	13,626	83,218	40.4	33.1	81.9
Hamilton.....	243,379	163,968	55,579	24,565	29,683	1,331	23,832	67.4	22.8	33.9
Hancock.....	186,190	126,622	40,167	20,178	18,750	1,239	19,401	68.0	21.6	31.7
Harrison.....	288,405	110,809	63,327	28,175	25,076	10,076	114,269	38.4	22.0	57.1
Henricks.....	254,159	150,895	42,322	42,518	47,136	4,668	8,942	59.4	37.1	62.5
Henry.....	244,432	149,579	64,925	39,039	21,867	4,019	29,928	61.2	26.6	43.4
Howard.....	184,020	128,118	39,314	20,921	16,663	1,760	16,528	69.6	21.4	30.7
Huntington.....	234,149	149,937	58,705	25,263	29,255	4,187	25,487	64.0	25.1	39.1
Jackson.....	294,597	134,296	68,107	26,378	35,370	6,359	92,194	45.6	23.1	50.7

Jasper.....	307,028	156,034	91,546	34,704	41,981	14,861	59,448	50.8	29.8	58.7
Jay.....	236,191	147,120	68,183	33,745	31,573	13,888	19,888	42.6	29.0	46.3
Jefferson.....	219,572	73,328	83,491	22,536	30,888	30,067	60,753	32.3	38.0	110.8
Jennings.....	219,613	82,680	66,527	31,381	26,910	8,236	70,404	37.6	30.3	80.5
Johnson.....	197,403	134,679	43,178	17,730	22,318	3,130	19,546	68.2	21.9	32.1
Knox.....	309,087	188,725	48,851	19,495	25,175	4,181	71,511	61.1	15.8	25.9
Kosciusko.....	316,833	174,392	83,389	31,317	33,421	13,651	59,072	55.0	26.3	47.8
Lafayette.....	230,576	128,099	59,309	15,843	27,408	20,058	43,168	55.6	25.7	46.3
Lake.....	224,204	135,117	51,101	24,004	17,310	9,847	37,926	60.3	22.8	37.8
Laporte.....	340,603	179,343	68,564	23,699	49,697	24,055	92,696	52.7	20.1	38.2
Lawrence.....	239,799	80,276	99,971	37,993	49,697	12,281	79,552	30.9	38.5	124.5
Madison.....	289,757	176,875	68,430	36,580	28,454	3,396	24,422	65.6	25.4	38.7
Martion.....	288,510	142,793	45,895	15,216	28,053	2,626	29,822	65.3	21.0	32.1
Marshall.....	268,106	144,944	66,593	19,366	29,210	17,927	56,659	54.1	24.8	45.9
Martin.....	194,877	156,436	94,198	32,866	28,333	32,490	45,243	28.4	48.3	109.9
Miami.....	223,604	136,702	63,270	31,379	26,114	7,747	30,492	50.1	27.6	46.6
Monroe.....	228,541	71,830	81,136	30,185	33,311	11,640	28,375	31.4	33.5	113.0
Montgomery.....	307,195	192,449	86,439	29,702	32,352	4,355	72,307	62.6	28.1	44.9
Morgan.....	210,211	114,780	80,235	31,201	52,793	5,241	36,196	54.8	37.1	47.4
Newton.....	231,935	138,796	64,429	27,216	32,279	4,934	28,710	59.8	27.8	46.4
Noble.....	255,759	137,395	76,127	27,000	30,464	18,663	42,237	53.7	29.8	55.4
Ohio.....	52,824	19,683	18,019	7,178	5,204	5,547	15,122	37.3	34.1	91.5
Orange.....	297,843	80,696	78,389	32,022	27,668	18,699	75,758	33.9	83.0	97.1
Owen.....	290,962	73,122	102,348	44,193	46,503	11,652	55,492	31.7	44.3	140.0
Parke.....	256,392	122,601	95,289	18,999	70,170	6,120	38,502	47.8	37.2	77.7
Perry.....	212,939	69,286	48,320	12,151	25,683	10,486	95,353	32.5	22.7	69.7
Pike.....	194,723	88,415	48,698	37,790	7,173	3,735	57,580	55.1	25.0	55.1
Porter.....	290,329	133,548	65,361	26,617	26,829	11,915	40,420	45.8	27.3	48.9
Posey.....	238,834	165,348	79,917	12,723	9,669	11,525	49,569	69.2	10.0	14.5
Pulaski.....	238,170	119,138	73,931	34,051	34,892	11,018	59,101	46.1	31.0	67.1
Putnam.....	232,399	131,995	122,725	31,338	80,478	10,769	37,679	45.1	42.0	93.0
Randolph.....	260,332	179,892	68,867	33,342	32,049	3,466	31,583	64.2	24.6	38.3
Ripley.....	273,171	116,030	103,645	122,009	27,913	13,123	(c)	42.5	59.9	141.0
Rush.....	263,872	164,177	56,974	27,685	26,315	2,974	32,721	64.7	22.4	34.7
Saint Joseph.....	253,463	137,322	48,952	15,944	20,063	12,945	67,189	54.2	19.3	35.6
Scott.....	111,341	45,779	24,342	11,520	9,361	3,461	41,220	41.1	21.9	53.4
Shelby.....	176,796	41,450	16,737	16,737	19,717	4,996	33,657	70.2	16.5	29.9
Spencer.....	236,509	128,702	38,536	22,039	10,921	5,576	69,361	54.4	16.3	29.9
Stark.....	158,009	65,181	39,038	10,948	22,323	5,767	53,790	41.3	24.7	59.9
Steuben.....	183,911	96,374	56,018	21,690	20,166	14,122	31,519	52.4	30.5	58.1
Sullivan.....	225,009	134,667	66,261	36,600	25,330	4,331	54,081	82.8	26.0	49.2
Switzerland.....	196,856	47,728	45,717	23,244	13,473	9,000	43,411	34.9	33.4	95.8
Tipton.....	239,305	213,992	61,260	20,553	28,548	6,159	24,053	71.5	20.5	28.6
Vanderburgh.....	102,152	42,054	32,279	23,296	18,030	8,728	9,791	68.3	25.7	37.6
Vermilion.....	132,648	88,702	24,010	8,311	14,230	3,292	14,663	54.1	31.6	58.4
Vigo.....	149,268	89,637	19,750	10,919	23,406	2,509	19,936	66.9	28.1	27.1
Wabash.....	230,576	129,225	54,317	18,475	26,528	3,426	21,881	60.1	25.3	42.0
Warren.....	219,327	146,606	34,870	34,870	34,870	6,004	30,116	58.8	29.1	49.5
Warrick.....	217,090	145,730	48,997	21,754	21,014	3,229	22,333	67.1	22.6	33.6

^a See table of counties reporting an excessive acreage in pasture, on page 13.

TABLE II.—*Pasture land on farms in the United States, by counties (1910 census)*—Continued.

County.	Total land in farms.	Land in crops.	Pasture land.			All other farm land.	Percentage of total farm land devoted to—		Acres in pasture per 100 acres in crops.	
			Total.	Improved.	Woodland.		Other.	Crops.		Pasture.
INDIANA—Continued.										
Warriek.....	235,234	128,983	43,363	31,238	8,006	4,119	54.8	18.4	83.6	
Washington.....	310,059	116,929	90,374	51,142	27,667	11,765	37.7	29.2	77.5	
Wayne.....	247,035	139,609	71,307	32,426	33,926	4,955	56.5	28.9	51.1	
Wells.....	229,113	141,255	59,825	30,912	27,352	1,961	62.5	26.5	42.4	
White.....	314,583	196,839	78,146	44,337	26,092	7,717	39.8	24.8	39.7	
Whitley.....	292,763	110,781	58,954	26,113	29,160	3,681	54.6	29.1	53.2	
Total.....	21,299,823	11,506,323	5,086,469	2,551,771	2,418,642	716,056	54.0	26.7	49.4	
IOWA.										
Adair.....	356,756	199,439	128,294	105,255	14,024	9,015	55.9	35.9	64.3	
Adams.....	211,719	140,632	102,434	82,786	16,055	3,533	53.7	39.1	72.8	
Allamakee.....	373,033	155,594	106,806	44,320	97,766	24,770	50.573	44.7	107.2	
Appanoose.....	307,571	136,667	143,425	80,702	47,882	5,841	44.4	46.6	105.0	
Arden.....	281,629	186,649	84,659	71,458	8,725	4,476	66.3	30.1	45.4	
Benton.....	440,553	289,637	123,219	83,647	20,147	19,455	36.667	27.1	42.5	
Blackhawk.....	340,103	221,378	98,350	62,904	22,281	13,165	65.1	28.9	44.4	
Boone.....	311,376	223,243	90,059	45,754	23,891	20,414	65.4	26.4	40.3	
Bremer.....	267,528	176,434	79,566	39,813	18,084	21,669	11,528	29.7	45.1	
Buchanan.....	351,498	221,212	112,414	60,183	24,118	28,143	17,842	32.0	50.8	
Buena Vista.....	349,285	244,464	83,732	58,533	3,839	21,020	21,099	24.0	34.3	
Butler.....	352,854	227,617	99,202	54,854	15,696	28,652	26,035	28.1	43.6	
Calhoun.....	349,375	234,684	80,781	56,140	4,895	19,746	33,910	23.1	34.4	
Carroll.....	351,936	236,553	81,659	61,173	7,465	13,021	33,724	23.2	34.5	
Cass.....	354,447	223,862	114,702	94,440	13,256	7,006	15,883	32.3	51.2	
Cedar.....	350,505	211,703	106,892	71,672	26,632	8,588	31,850	30.5	50.5	
Cerro Gordo.....	336,016	227,125	85,979	53,470	11,182	21,327	23,512	25.5	37.9	
Cherokee.....	361,435	249,943	107,067	57,326	80,900	28,781	67.5	46.2	66.8	
Chickasaw.....	307,522	189,586	90,312	44,890	22,557	23,865	61.6	29.4	47.6	
Clarke.....	290,944	133,078	107,013	63,734	28,339	14,940	20,833	41.0	80.4	
Clay.....	335,912	215,545	98,156	67,509	8,641	17,006	27,211	64.2	43.1	
Clayton.....	461,417	236,728	174,976	66,985	87,466	20,825	49,713	51.3	73.9	
Clinton.....	423,469	251,517	152,912	93,427	26,285	27,200	19,040	59.4	60.8	

Crawford.....	439,451	288,869	127,217	94,632	18,825	16,760	23,265	65.7	28.9	44.0
Dallas.....	356,181	222,576	85,418	44,304	26,359	7,755	48,187	62.5	24.0	38.4
Davis.....	311,422	145,553	138,749	75,813	55,515	7,421	27,120	46.7	44.5	95.4
Decatur.....	319,069	147,279	133,388	70,188	48,270	14,930	38,402	46.2	41.8	90.6
Delaware.....	350,223	218,576	116,592	63,722	30,110	22,760	14,775	62.5	33.3	53.3
Des Moines.....	301,933	130,033	81,320	33,682	35,952	11,681	38,692	52.0	32.5	62.5
Dickinson.....	208,321	129,773	54,040	32,652	3,553	17,825	21,530	62.3	25.9	41.6
Dubuque.....	306,390	202,020	142,802	54,381	63,190	25,228	21,559	55.1	20.0	70.7
Emmet.....	224,054	137,615	55,638	36,111	4,563	33,964	23,801	61.4	23.3	41.1
Fayette.....	447,459	238,238	133,511	83,038	36,003	39,680	23,680	57.7	35.7	61.8
Floyd.....	298,544	201,481	79,550	48,394	13,676	13,480	17,513	68.7	26.6	39.5
Franklin.....	366,833	245,251	88,839	46,119	8,995	22,740	67.5	68.7	24.9	36.2
Fremont.....	206,977	184,488	79,033	53,641	19,727	5,665	33,456	62.1	26.6	42.8
Greene.....	357,966	237,543	93,214	53,027	15,758	27,149	66.4	66.4	26.0	39.2
Grundy.....	318,290	223,530	79,528	53,585	4,458	21,485	15,222	70.2	25.0	35.6
Guthrie.....	354,200	202,875	113,629	65,970	33,789	13,870	37,696	57.3	32.1	56.0
Hamilton.....	357,803	232,457	88,298	50,756	10,776	26,766	37,048	65.0	23.7	38.0
Hancock.....	340,298	219,800	80,579	57,428	3,035	20,116	39,919	64.6	24.7	36.7
Hardin.....	351,784	219,870	95,791	57,486	22,253	16,052	36,123	62.5	27.2	44.0
Harrison.....	408,097	253,771	111,739	54,937	38,472	18,330	42,587	62.2	27.4	43.0
Henry.....	285,749	147,796	94,543	44,748	33,293	16,500	21,410	56.0	35.8	64.0
Howard.....	293,402	172,206	79,198	40,970	11,709	17,519	33,498	60.3	27.7	46.0
Humboldt.....	290,116	180,140	63,352	41,408	4,833	17,111	23,018	60.9	23.5	35.2
Iowa.....	270,052	195,745	61,402	32,113	2,764	6,635	12,855	72.5	22.8	31.4
Jackson.....	300,024	191,961	122,419	81,681	30,756	9,982	45,614	53.3	34.0	63.8
Jasper.....	389,773	177,994	185,307	71,754	89,426	24,187	26,412	45.7	47.5	104.2
Jasper.....	453,901	262,946	152,908	104,992	34,224	13,692	35,017	57.9	33.7	58.2
Jefferson.....	203,260	138,632	107,423	48,949	45,820	12,634	17,205	52.7	40.8	77.5
Johnson.....	378,334	214,042	131,625	80,164	41,786	9,675	32,667	56.6	34.8	61.5
Jones.....	341,433	178,311	138,405	80,878	41,957	15,630	21,457	52.3	40.5	77.6
Keokuk.....	357,571	201,173	127,626	78,645	40,895	8,083	28,772	56.2	35.7	63.5
Kossuth.....	566,040	393,241	133,320	78,650	7,565	47,105	69,843	64.1	23.5	36.7
Lee.....	300,660	147,551	64,179	33,655	53,525	22,172	36,031	47.5	40.9	86.7
Linn.....	431,055	259,762	165,883	83,257	37,232	29,101	5,410	60.3	27.3	45.3
Louis.....	236,624	130,894	76,186	33,695	41,913	15,258	23,554	55.2	32.1	58.2
Lucas.....	263,659	121,721	112,000	57,556	4,913	12,619	23,848	46.2	42.5	92.1
Lyons.....	352,032	272,156	141,583	49,403	7,896	14,344	8,293	46.8	20.3	26.3
Madison.....	346,541	172,494	142,153	83,940	35,493	19,730	31,884	49.8	41.0	80.5
Manassas.....	350,531	196,147	118,616	73,844	34,002	10,770	35,768	56.0	33.8	60.5
Marion.....	343,949	179,849	129,532	68,598	46,992	13,942	34,568	52.3	37.7	72.0
Marshall.....	298,497	99,441	70,617	20,278	8,516	20,031	66.6	66.6	27.8	41.7
Mills.....	260,648	165,256	75,075	44,899	19,593	10,583	20,307	63.4	28.8	45.4
Mitchell.....	257,046	195,206	67,150	44,292	13,981	8,967	24,090	68.0	23.4	34.4
Monona.....	400,319	227,217	104,318	33,995	39,045	31,326	68,764	56.8	26.0	45.9
Monroe.....	257,931	104,820	121,279	64,806	45,352	11,121	26,652	42.6	47.0	110.4
Montgomery.....	296,403	165,170	79,227	61,755	13,015	4,457	22,006	62.0	29.7	48.0
Muscatine.....	259,046	150,157	87,293	44,535	30,371	12,357	21,626	58.0	33.7	58.1
O'Brien.....	345,873	232,800	188,529	55,995	16,521	116,010	(a)	67.3	54.5	81.0
Osceola.....	236,406	162,869	54,614	46,968	2,550	5,056	19,923	68.9	23.1	33.5

a See table of counties reporting an excessive acreage in pasture, on page 13.

TABLE II.—Pasture land on farms in the United States, by counties (1910 census)—Continued.

County.	Total land in farms.	Land in crops.	Pasture land.				All other farm land.	Percentage of total farm land de- voted to—		Acres in pasture per 100 acres in crops.
			Total.			Other.		Crops.	Pasture.	
			Total.	Improved.	Woodland.					
IOWA—Continued.										
Page.....	327, 809	191, 356	108, 382	84, 741	17, 036	6, 605	28, 071	58.4	33.1	56.6
Palo Alto.....	324, 418	198, 789	80, 991	55, 706	3, 213	22, 072	34, 688	61.3	25.0	40.7
Plymouth.....	539, 553	382, 967	121, 865	86, 277	8, 770	27, 118	44, 701	71.0	22.6	31.8
Pocahontas.....	351, 777	238, 798	82, 147	53, 014	6, 355	22, 748	30, 832	68.0	23.3	34.4
Polk.....	339, 196	211, 331	90, 106	45, 684	30, 483	13, 939	37, 759	62.3	26.6	42.6
Pottawattamie.....	574, 538	372, 876	a 143, 897	a 102, 452	a 24, 945	a 16, 500	57, 765	64.9	25.0	38.6
Poweshiek.....	359, 765	204, 002	124, 990	97, 878	17, 703	9, 344	30, 773	56.7	34.7	61.3
Ringold.....	325, 483	165, 891	132, 302	96, 763	28, 831	6, 708	27, 290	51.0	40.6	79.8
Sac.....	360, 529	249, 523	83, 692	53, 102	5, 918	24, 612	27, 314	69.2	23.2	33.5
Scott.....	276, 073	183, 408	77, 171	47, 057	17, 412	12, 705	15, 491	66.4	27.9	42.1
Shelby.....	370, 317	253, 307	96, 008	72, 183	15, 063	9, 362	20, 402	68.4	26.1	38.1
Shiawassee.....	475, 438	357, 762	96, 878	69, 090	6, 530	21, 258	20, 798	75.2	20.4	27.1
Stout.....	351, 286	241, 508	86, 304	52, 476	18, 318	15, 510	23, 474	68.7	24.6	35.7
Story.....	440, 404	270, 173	142, 426	103, 434	26, 121	12, 871	27, 805	61.3	32.3	52.7
Tama.....	385, 807	170, 283	126, 984	94, 823	29, 048	3, 413	38, 210	50.8	37.8	74.6
Taylor.....	252, 807	124, 348	91, 346	55, 313	21, 039	14, 864	32, 113	51.2	36.1	70.6
Union.....	300, 515	127, 438	124, 799	48, 963	66, 204	9, 632	48, 278	42.4	41.5	98.0
Van Buren.....	259, 829	184, 112	106, 115	57, 532	40, 612	7, 971	19, 602	51.6	40.8	79.1
Wapello.....	342, 113	170, 170	136, 271	91, 168	39, 578	5, 525	35, 672	49.7	39.8	80.1
Warren.....	338, 975	192, 517	118, 634	71, 957	35, 572	11, 105	27, 824	56.8	35.0	61.6
Washington.....	323, 921	178, 718	117, 923	87, 746	22, 902	7, 275	27, 280	55.2	36.4	66.0
Wayne.....	423, 492	276, 491	105, 399	47, 803	23, 827	33, 793	41, 602	65.3	24.9	38.1
Webster.....	327, 666	144, 778	62, 919	38, 614	3, 583	20, 722	29, 969	60.9	26.5	43.4
Winnebago.....	425, 917	239, 998	138, 021	62, 336	48, 743	26, 945	47, 895	56.3	32.4	57.5
Winneshek.....	524, 138	356, 302	123, 967	78, 248	23, 592	22, 127	43, 809	68.0	23.6	34.8
Woodbury.....	247, 982	162, 418	61, 262	35, 998	6, 525	18, 739	24, 302	65.5	24.7	37.7
Wright.....	355, 311	240, 569	82, 782	45, 066	6, 150	31, 566	31, 950	67.7	23.3	34.7
Total.....	33, 930, 688	20, 532, 138	10, 655, 616	6, 271, 197	2, 030, 007	1, 754, 412	2, 742, 934	60.5	31.4	51.9

KANSAS.

Allen.....	296,323	159,833	82,802	53,369	10,630	18,923	53,028	53.9	28.0	51.9
Anderson.....	336,479	174,219	114,275	50,939	15,407	47,929	47,985	51.8	34.0	65.6
Archison.....	249,339	149,911	63,320	31,759	26,797	4,764	36,108	60.1	25.4	42.2
Barber.....	648,402	180,708	400,678	42,037	16,700	341,911	67,016	27.9	61.8	221.7
Barton.....	527,706	364,064	128,346	65,915	17,776	44,655	35,296	69.0	24.3	35.3
Bourlon.....	370,972	179,355	111,540	52,023	28,472	31,045	80,077	48.3	30.1	62.2
Brown.....	348,259	233,757	101,936	47,425	23,399	10,112	33,566	67.1	23.2	34.6
Butler.....	857,062	345,683	428,122	232,064	28,344	167,714	89,257	40.3	50.0	123.8
Chase.....	458,043	101,966	321,061	62,636	52,802	205,563	35,016	22.3	70.1	314.8
Chautauqua.....	370,049	120,638	210,742	29,883	58,776	121,953	35,069	32.6	57.0	174.7
Cherokee.....	322,692	173,230	75,410	45,353	20,194	9,803	74,052	53.7	23.4	43.5
Cheyenne.....	411,400	129,148	149,334	15,305	1,560	129,409	132,918	15.4	109.1	709.8
Clark.....	533,903	82,082	582,622	144,738	1,953	435,931	(b)	31.4	36.3	115.7
Cloud.....	398,504	256,417	113,200	58,494	12,752	41,954	28,887	64.3	28.4	44.1
Coffey.....	433,112	263,890	119,781	33,156	13,252	73,373	49,441	60.9	27.7	45.4
Comanche.....	400,535	217,610	125,535	89,323	6,396	238,757	8,338	54.3	31.3	57.7
Cowley.....	653,470	297,555	312,735	78,006	30,570	20,582	43,180	45.5	47.9	105.1
Crawford.....	338,585	185,987	92,620	43,969	18,525	30,126	59,978	45.9	27.4	49.8
Decatur.....	531,421	299,810	157,833	21,616	7,091	129,126	133,778	45.1	29.7	65.8
Dickinson.....	515,127	289,208	158,268	84,723	14,580	58,965	37,651	56.1	30.7	54.7
Doniphan.....	230,918	138,669	54,324	32,627	17,612	4,085	37,235	60.2	23.6	39.2
Douglas.....	284,016	146,553	92,112	43,144	23,450	25,948	45,321	51.6	32.4	62.9
Edwards.....	354,285	188,786	97,504	39,576	6,078	31,910	67,925	53.3	27.5	51.7
Ellis.....	368,558	188,839	190,364	45,322	21,565	123,277	39,355	37.7	51.6	137.1
Ellsworth.....	325,128	234,493	204,958	71,691	4,096	129,171	85,677	44.7	39.0	87.4
Ellsworth.....	433,573	210,287	173,550	39,530	9,674	124,346	49,736	48.5	40.0	82.5
Fenney.....	312,475	58,270	112,677	25,770	31,357	55,550	141,528	18.6	36.1	193.4
Ford.....	570,390	231,850	190,115	70,165	1,949	118,001	148,425	40.6	33.3	82.0
Franklin.....	347,507	168,796	117,075	61,651	26,427	28,997	61,636	48.6	33.7	69.4
Geary.....	225,728	92,812	115,412	13,623	2,266	99,523	17,504	41.1	51.1	124.4
Gove.....	496,500	173,565	213,249	61,174	965	151,110	109,680	35.0	43.0	122.8
Graham.....	524,764	249,498	167,739	28,894	15,326	123,519	107,527	47.5	32.0	67.2
Grant.....	147,332	12,800	123,348	41,636	4,040	77,672	11,124	8.7	83.7	939.2
Gray.....	232,803	64,888	101,919	1,105	16,630	90,184	63,996	27.9	43.8	137.1
Greene.....	108,774	12,675	112,003	9,026	.....	102,467	(b)	11.6	103.0	884.0
Greenwood.....	646,416	232,246	341,782	63,519	14,705	261,228	72,388	33.9	32.9	147.2
Hamilton.....	171,530	28,363	75,229	18,294	1,010	55,925	68,258	16.5	43.8	265.3
Harper.....	476,564	234,476	134,259	54,323	12,134	67,792	47,829	61.8	28.2	45.6
Harvey.....	325,624	217,147	76,078	54,732	3,747	17,599	32,399	66.7	23.4	35.0
Haskell.....	88,278	9,860	735	.....	15	77,683	11.2	7.5	8	7.5
Hodgeman.....	399,606	76,347	315,122	1,154	59,314	254,654	8,137	19.1	78.9	412.7
Jackson.....	393,509	234,133	115,168	63,722	17,735	33,711	44,208	59.5	29.3	49.2
Jefferson.....	336,472	184,850	99,470	51,809	33,211	14,450	52,152	54.9	29.6	53.8
Jewell.....	501,241	317,115	158,974	68,068	37,633	53,223	85,152	56.5	28.3	50.1
Johnson.....	281,314	168,360	76,503	42,975	20,120	13,408	36,451	59.8	27.2	45.4

b See table of counties reporting an excessive acreage in pasture, on page 13.

a Estimated.

TABLE II.—*Pasture land on farms in the United States, by counties (1910 census)*—Continued.

County.	Total land in farms.	Land in crops.	Pasture land.				All other farm land.	Percentage of total farm land voted to—		Acres in pasture per 100 acres in crops.
			Total.	Improved.	Woodland.	Other.		Crops.	Pasture.	
KANSAS—Continued.										
Kearny.....	191,855	42,734	77,797	9,041	1,249	67,507	71,324	22.3	40.5	182.1
Kingman.....	498,721	273,058	196,835	118,361	5,252	73,222	28,818	54.7	39.5	72.1
Kiowa.....	418,760	183,637	189,710	52,145	2,771	134,794	43,383	43.9	45.3	103.3
Labelle.....	391,753	204,405	108,857	62,257	14,377	31,753	78,961	52.2	27.7	53.0
Lane.....	321,942	72,045	169,763	97,658	2,387	69,718	80,134	22.4	52.7	235.6
Leavenworth.....	269,880	142,666	92,739	40,654	44,202	7,883	134,445	52.9	34.4	65.0
Lincoln.....	442,639	204,847	185,233	37,023	14,281	113,929	52,559	46.3	41.9	90.4
Linn.....	356,837	172,540	116,318	32,114	33,044	31,160	97,979	48.4	32.6	67.4
Logan.....	454,561	94,663	265,120	80,378	1,346	183,396	94,778	20.8	58.3	285.1
Lyon.....	525,726	239,173	220,339	92,034	31,729	96,576	66,214	45.5	41.9	92.1
McPherson.....	556,232	364,395	136,772	75,328	8,084	53,360	55,065	65.5	21.6	37.5
Marion.....	583,845	333,778	218,365	82,459	25,299	110,607	31,702	57.2	37.4	65.4
Marshall.....	558,818	352,514	151,063	61,004	25,580	64,419	35,301	63.1	27.0	42.8
Meade.....	426,418	108,199	180,249	45,728	1,743	132,778	137,970	25.4	42.3	166.6
Miami.....	339,305	185,827	117,234	65,613	31,821	19,800	56,244	51.7	32.6	63.1
Michell.....	444,528	252,155	130,545	43,543	9,614	77,388	61,828	56.7	29.4	51.8
Montgomery.....	367,325	179,775	118,472	56,644	30,821	31,007	69,078	48.9	32.3	65.9
Morris.....	411,654	182,394	196,397	62,665	11,081	122,651	32,863	44.3	47.7	107.7
Morton.....	139,514	13,466	124,885	2,320	.....	122,565	1,163	9.7	89.5	927.1
Nemaha.....	438,376	264,589	119,268	71,923	29,095	17,650	54,519	60.4	27.2	45.1
Neosho.....	328,453	174,087	93,061	50,689	16,910	25,462	61,305	53.0	28.3	53.5
Ness.....	626,749	137,869	398,698	82,931	13,012	302,755	90,182	22.0	63.6	289.1
Norton.....	532,918	204,859	191,716	31,231	8,087	132,398	136,343	38.4	36.0	93.6
Osage.....	438,617	210,184	162,459	70,239	26,314	65,906	65,974	47.9	37.0	77.3
Osburne.....	554,868	267,242	244,529	57,715	38,706	148,108	43,097	48.2	44.1	91.5
Ottawa.....	435,387	208,358	179,501	41,971	5,702	131,828	47,528	47.9	41.2	86.1
Pawnee.....	444,308	279,382	103,601	63,523	1,975	38,103	61,325	62.9	23.3	37.0
Phillips.....	553,550	310,387	181,124	90,480	17,491	73,153	62,039	56.1	32.7	58.4
Portawatomie.....	505,413	222,179	234,887	84,053	34,863	115,971	48,347	44.0	46.5	105.7
Pratt.....	414,779	258,458	97,581	59,412	5,638	32,531	58,513	62.3	23.5	37.7
Rawlins.....	577,575	208,426	287,066	63,732	23,455	199,879	87,033	35.2	49.7	37.0
Reano.....	735,858	476,735	176,351	81,571	30,508	64,502	82,742	64.8	24.0	36.0
Republic.....	441,803	283,786	105,668	39,361	20,675	46,432	42,349	66.5	23.9	39.1
Rice.....	443,416	288,422	112,789	46,728	7,023	39,038	42,205	42.1	25.4	113.8
Riley.....	377,576	159,079	181,076	30,587	20,151	130,338	37,421	42.1	48.0	66.8
Rooks.....	539,349	272,204	181,824	53,540	13,698	114,586	85,321	50.5	33.7	66.8

Rush.....	431,939	225,819	146,456	51,503	3,369	91,484	59,064	52.3	33.9	46.9
Russell.....	524,806	224,933	230,255	46,831	18,645	185,279	49,708	42.9	47.7	111.3
Saine.....	248,215	149,311	149,311	48,964	4,381	53,414	27,424	58.4	68.7	60.2
Scott.....	265,750	71,241	182,514	129,095	5	38,719	11,995	26.8	21.0	256.2
Sedgwick.....	695,889	406,659	127,037	78,198	10,129	68,800	72,193	67.1	46.6	194.7
Seward.....	211,274	50,538	98,410	29,549	61	31,062	62,326	23.9	29.9	54.7
Shawnee.....	312,716	171,051	93,561	48,884	13,615	61,062	48,104	54.7	62.6	314.3
Sheridan.....	493,877	201,477	122,860	46,292	3,391	73,177	69,540	40.8	24.9	61.0
Sherman.....	440,105	87,710	275,700	104,539	3,668	170,804	76,935	19.9	62.6	314.3
Smith.....	541,637	308,685	171,504	64,667	44,977	61,800	61,438	57.0	31.7	55.6
Stafford.....	450,687	338,043	98,288	46,598	2,308	49,382	41,356	68.3	21.8	31.9
Stanton.....	159,422	15,822	2,525	.....	.....	2,525	136,075	10.2	1.6	16.0
Stevens.....	224,770	42,684	130,336	48,580	.....	81,746	51,760	19.0	58.0	305.4
Sumner.....	717,507	487,181	157,647	83,728	12,585	58,334	79,576	67.9	92.0	52.4
Thomas.....	536,970	220,721	199,031	87,157	20,559	91,315	116,318	41.2	37.1	99.2
Trego.....	429,672	161,458	216,214	93,000	1,495	121,779	32,000	37.6	50.3	133.9
Wauvasee.....	477,806	181,722	245,935	46,352	13,537	185,836	30,149	38.0	51.5	135.4
Wallace.....	335,435	271,880	271,880	57,670	2,390	171,820	21,696	10.7	81.9	707.4
Washington.....	347,135	335,947	139,914	53,570	30,996	75,348	51,274	61.4	21.2	47.6
Wichita.....	263,153	103,765	41,784	53,627	4,454	61,527	64,970	16.9	51.1	301.5
Wilson.....	330,169	150,786	119,013	53,627	24,043	41,373	60,361	45.7	36.0	78.9
Woodson.....	279,225	142,485	98,397	53,735	17,468	27,254	38,353	51.0	35.2	69.1
Wyandotte.....	72,521	40,280	19,808	7,205	11,367	1,236	12,436	55.5	27.3	49.2
Total.....	43,384,799	21,063,126	17,115,638	5,925,390	1,647,363	9,542,685	6,176,035	46.3	39.5	85.2

KENTUCKY.

Adair.....	224,910	63,580	44,696	30,786	10,608	3,302	116,034	28.3	19.9	70.3
Allen.....	204,681	62,066	16,238	27,296	6,699	6,699	92,387	30.3	21.5	80.9
Anderson.....	124,273	30,931	59,045	36,001	13,169	9,925	34,247	24.9	47.9	191.0
Ballard.....	145,185	64,342	20,021	16,191	3,644	6,843	60,822	44.3	13.8	31.1
Barren.....	297,893	101,677	77,028	57,342	12,843	6,735	119,188	34.1	23.9	75.7
Bath.....	193,130	40,757	64,587	27,943	29,889	6,735	37,736	28.5	43.1	138.4
Bell.....	97,656	16,831	9,831	5,354	2,917	9,800	71,274	17.2	10.1	58.5
Boone.....	143,693	42,565	76,687	66,687	3,920	4,080	26,441	29.2	52.6	180.2
Bourbon.....	189,746	65,446	107,651	38,084	47,630	1,937	16,699	34.5	56.7	104.5
Boyle.....	71,570	16,500	35,236	29,104	4,665	1,467	19,744	23.2	49.2	212.4
Boyd.....	110,518	41,676	38,794	20,004	11,683	2,406	35,048	37.7	30.6	81.1
Bracken.....	122,451	31,767	44,493	37,063	5,024	2,466	46,191	25.9	36.3	140.1
Breathitt.....	261,943	37,137	20,207	9,877	5,362	4,968	204,599	14.2	7.7	54.4
Breckinridge.....	339,369	96,437	72,378	49,541	15,502	7,733	170,554	28.4	20.5	75.1
Bullitt.....	157,051	38,611	32,228	14,560	9,723	7,945	86,212	24.6	21.3	83.5
Butler.....	242,729	62,257	36,183	20,129	11,614	4,440	144,289	25.6	19.9	58.1
Caldwell.....	165,442	49,195	53,232	39,066	12,911	1,255	93,015	25.2	27.2	108.2
Calloway.....	241,372	77,894	33,417	20,083	11,687	1,647	130,061	32.3	13.8	42.9
Campbell.....	88,274	39,080	25,590	18,145	3,124	4,251	33,674	44.3	28.9	65.3
Carlisle.....	103,900	47,103	19,357	9,624	9,132	751	37,260	45.3	18.8	41.5

TABLE II.—*Pasture land on farms in the United States, by counties (1910 census)*—Continued.

County.	Total land in farms.	Land in crops.	Pasture land.			All other farm land.	Percentage of total farm land devoted to—		Acres in pasture per 100 acres in crops.	
			Total.	Improved.	Woodland.		Other.	Crops.		Pasture.
KENTUCKY—Continued.										
Carroll.....	80,519	22,165	38,941	21,123	13,202	4,616	19,413	27.5	48.4	175.7
Carter.....	241,751	50,851	61,891	40,183	15,291	6,417	129,006	21.0	25.6	121.7
Cassy.....	223,113	48,617	35,214	26,249	4,505	4,460	139,312	21.8	15.8	72.4
Christian.....	417,763	154,292	76,228	59,515	11,866	4,817	187,243	36.9	18.2	49.4
Clark.....	149,955	39,233	89,319	60,268	23,407	3,619	21,383	26.2	59.6	227.7
Clay.....	244,214	46,884	25,418	17,100	4,645	3,673	171,912	19.2	10.4	54.2
Crittenden.....	119,926	32,001	16,500	11,425	3,338	1,737	71,425	26.7	13.8	51.6
Crittenden.....	216,088	66,377	53,665	39,679	7,524	6,462	96,046	30.7	24.8	81.0
Cumberland.....	104,757	31,169	22,307	10,505	8,963	2,839	111,981	18.9	13.5	71.6
Daviess.....	267,062	118,479	75,709	53,351	3,030	17,308	72,874	44.4	28.4	63.9
Edmonson.....	184,382	36,031	25,241	17,628	3,803	3,810	123,110	19.5	13.7	70.1
Elliott.....	149,698	30,696	41,239	22,697	10,368	8,174	77,763	20.5	27.5	134.3
Estill.....	142,824	29,497	38,893	16,748	18,085	4,060	74,434	24.0	27.2	131.9
Fayette.....	165,541	72,765	66,683	57,375	6,714	2,594	26,093	44.0	40.3	91.6
Fleming.....	213,666	64,659	89,007	69,010	11,908	8,689	59,400	30.3	41.9	138.6
Floyd.....	235,190	38,870	33,811	16,863	13,580	3,368	162,489	16.5	14.4	83.9
Franklin.....	125,330	38,978	54,869	40,486	10,029	4,354	31,483	31.1	43.8	140.8
Fulton.....	89,892	53,140	12,811	9,813	2,621	377	23,941	59.1	14.3	24.1
Gallatin.....	58,620	15,834	26,040	16,423	5,951	3,666	16,746	27.0	44.4	164.5
Garrard.....	127,788	48,391	57,311	40,849	11,027	5,435	22,068	37.9	44.8	118.4
Grant.....	136,482	42,658	88,319	64,776	14,466	9,077	25,305	27.3	56.4	207.0
Graves.....	335,830	125,925	62,574	44,984	13,288	4,302	147,331	37.5	18.6	49.7
Grayson.....	295,551	88,282	74,869	50,477	17,146	7,246	132,400	29.9	25.3	84.1
Green.....	167,375	48,149	34,570	19,725	10,092	4,753	84,656	28.8	20.7	71.8
Greenup.....	197,021	39,275	52,386	23,226	23,061	6,099	105,360	19.9	26.6	133.4
Hancock.....	108,588	39,651	30,131	16,779	3,118	10,234	38,806	30.5	27.7	76.0
Hardin.....	367,128	108,111	118,508	84,169	21,767	12,572	140,509	29.4	32.3	109.6
Harlan.....	161,926	19,425	22,893	17,137	5,162	594	119,408	12.0	14.1	117.9
Harrison.....	192,819	57,205	100,648	75,102	9,982	15,474	34,996	29.7	52.2	175.9
Hart.....	246,407	59,457	68,969	44,417	16,540	8,012	117,981	24.1	28.0	116.0
Henderson.....	231,677	114,626	62,790	54,479	5,949	2,362	54,261	49.5	23.5	54.8
Henry.....	178,217	47,711	63,777	52,732	4,790	6,235	66,729	26.8	33.8	133.7
Hickman.....	138,494	68,342	48,310	27,073	15,058	6,179	16,812	51.2	36.2	70.7
Hopkins.....	298,293	92,232	67,457	40,368	15,531	11,558	138,574	30.9	22.6	73.1
Jackson.....	153,561	32,034	40,063	17,703	15,741	6,619	81,464	20.9	26.1	125.1
Jefferson.....	196,707	86,829	58,317	23,955	16,985	17,377	51,561	44.1	29.6	67.2

TABLE II.—*Pasture land on farms in the United States, by counties (1910 census)*—Continued.

County.	Total land in farms.	Land in crops.	Pasture land.				All other farm land.	Percentage of total farm land de- voted to—		Acres in pasture per 100 acres in crops.
			Total.	Improved.	Woodland.	Other.		Crops.	Pasture.	

KENTUCKY—Continued.										
Taylor.....	159,171	46,185	33,338	16,903	7,066	9,369	29.0	20.9	72.0	
Todd.....	224,735	80,452	34,635	24,611	8,705	1,319	35.8	15.4	43.0	
Trigg.....	257,670	59,839	42,061	27,965	10,729	3,367	23.2	16.3	70.3	
Trimble.....	91,631	27,612	39,434	19,256	18,183	8,995	30.2	43.0	142.7	
Union.....	201,831	116,324	52,062	37,065	15,045	4,193	37.8	23.8	44.8	
Warren.....	321,926	113,024	75,232	51,990	14,942	8,310	33.1	23.4	66.6	
Washington.....	185,848	54,315	47,422	56,567	17,299	13,556	29.2	47.0	161.0	
Wayne.....	317,375	55,222	41,719	28,401	10,505	22,043	17.4	13.2	75.5	
Webster.....	204,450	69,857	59,472	35,988	18,408	5,076	34.2	29.1	85.1	
Whitley.....	248,287	56,248	38,837	24,895	9,780	4,182	22.7	15.6	69.1	
Wolfe.....	137,508	29,156	34,309	20,381	11,518	2,410	21.2	25.0	117.7	
Woodford.....	121,320	54,780	41,037	22,543	16,106	2,388	45.2	33.8	74.9	
Total.....	22,189,127	6,253,012	5,810,535	3,828,564	1,388,619	593,352	28.2	26.2	92.9	

LOUISIANA.										
Acadia.....	273,932	135,550	59,670	43,176	14,419	2,075	49.5	21.8	44.0	
Ascension.....	104,253	43,154	6,723	2,306	4,321	96	41.4	6.4	13.6	
Assumption.....	93,112	54,069	3,808	1,447	3,424	937	56.8	6.1	10.7	
Avoyelles.....	207,883	101,869	23,514	8,411	12,246	2,857	49.0	11.3	23.1	
Bienville.....	294,980	82,391	16,881	8,278	7,757	846	79.9	5.7	20.5	
Bossier.....	245,914	89,824	26,032	8,058	15,275	2,689	36.1	10.5	29.0	
Caddo.....	331,636	144,208	33,123	13,380	18,197	1,516	43.5	10.0	23.0	
Caldwell.....	490,594	147,890	165,711	63,707	54,641	47,693	30.1	33.8	11.2	
Cameron.....	124,016	18,282	9,733	3,329	5,706	698	14.7	7.8	53.2	
Catahoula.....	103,625	13,808	27,585	3,916	918	22,751	64.1	26.1	199.8	
Claborn.....	113,165	28,606	6,377	1,805	4,298	364	25.3	5.6	22.3	
Concordia.....	400,715	127,191	63,542	16,726	39,935	6,881	31.7	15.9	50.0	
De Soto.....	165,506	42,938	5,788	954	4,359	4,475	25.9	3.5	13.5	
East Baton Rouge.....	399,649	113,567	56,182	20,971	32,379	2,832	30.7	15.2	49.5	
East Carroll.....	186,110	62,817	34,308	13,734	18,027	2,547	33.8	18.4	54.6	
East Feliciana.....	138,188	41,813	3,733	2,076	88,985	90,179	39.6	4.5	14.8	
East Feliciana.....	194,978	77,165	44,034	20,565	15,753	7,716	33.6	22.6	57.1	

Franklin.....	124,221	34,032	20,025	4,419	14,885	721	70,164	27.4	16.1	58.8
Grant.....	122,662	27,245	16,978	3,390	13,057	522	78,439	22.2	12.8	62.3
Iberia.....	171,061	97,853	23,176	7,080	6,993	9,101	50,050	57.2	13.5	23.7
Iberville.....	104,728	33,273	1,388	1,404	9,321	1,633	50,067	50.9	1.3	2.6
Jackson.....	189,627	39,411	16,115	5,549	9,874	632	134,101	20.8	8.3	40.9
Jefferson.....	30,702	10,103	7,045	2,963	3,713	369	13,534	32.9	22.9	69.7
Jefferson.....	162,329	111,466	72,525	21,678	4,220	6,627	(c)	68.7	44.7	65.1
Lafayette.....	220,688	80,012	18,304	892	3,695	4,447	13,777	36.3	8.3	63.0
Lafayette.....	62,809	9,723	5,829	1,576	24,665	1,990	123,077	15.5	9.3	60.0
La Salle.....	238,712	69,933	45,702	19,472	8,710	385	90,900	21.1	19.1	65.4
Lincoln.....	20,232	11,576	4,481	1,047	1,883	128	60,798	34.0	12.2	57.2
Livingston.....	95,708	18,317	3,060	1,549	1,383	45	147,918	33.4	3.6	6.3
Madison.....	221,036	63,066	8,052	4,106	3,901	1,340	163,293	29.7	7.6	12.4
Morehouse.....	277,970	93,663	21,023	8,732	10,951	1,300	129,173	33.7	22.4	50.5
Natchitoches.....	10,220	3,723	1,880	1,173	10,407	1,300	4,617	38.4	18.4	29.0
Orleans.....	213,005	64,968	18,861	5,189	13,481	1,194	129,173	30.5	8.9	29.0
Ouachita.....	85,380	21,387	10,077	3,716	1,320	4,811	53,716	25.3	11.8	46.7
Plaquemines.....	203,591	85,818	15,766	3,225	12,078	463	99,007	45.6	7.7	17.8
Pointe Coupee.....	231,635	78,712	32,644	4,456	22,029	3,139	140,279	31.3	13.5	41.5
Rapides.....	146,198	42,902	12,236	3,244	8,390	602	91,060	29.3	8.4	28.5
Red River.....	146,456	47,911	9,435	2,163	6,952	320	89,110	32.7	6.4	19.7
Richland.....	234,863	55,372	30,826	8,966	19,832	2,028	148,665	23.6	13.1	55.7
Sabine.....	23,969	8,294	3,723	1,652	2,021	50	11,952	34.6	15.5	44.9
St. Bernard.....	46,732	17,196	766	558	2,117	91	28,770	36.8	1.6	4.5
St. Charles.....	104,201	29,789	9,214	5,010	2,373	1,631	65,198	28.6	8.8	30.9
St. Helena.....	80,321	45,613	3,114	1,704	2,725	685	31,594	56.8	3.9	6.8
St. James.....	45,145	27,230	1,378	213	1,163	2	16,537	60.3	3.1	5.1
St. John the Baptist.....	467,823	222,412	64,928	38,475	21,409	5,044	180,483	47.5	13.9	29.2
St. Landry.....	118,551	70,538	22,540	6,239	10,691	5,500	95,473	59.5	19.0	32.0
St. Martin.....	162,642	88,354	15,202	7,289	5,645	2,258	59,080	34.3	9.3	17.2
St. Mary.....	72,368	3,409	17,338	2,467	14,702	169	46,621	11.6	24.0	206.2
St. Tammany.....	110,058	34,855	13,180	2,458	9,689	1,033	95,521	22.4	9.4	42.0
Tangipahoa.....	141,726	65,079	21,501	6,074	12,211	3,216	95,456	35.8	11.8	33.0
Tensas.....	182,036	49,428	18,630	3,720	10,472	4,438	73,668	34.9	13.1	37.7
Terrebonne.....	364,112	90,411	43,000	9,464	32,007	1,529	230,701	24.8	11.8	47.6
Union.....	258,712	111,368	43,552	22,484	10,947	10,121	103,792	43.0	16.8	39.1
Vernon.....	109,545	19,561	8,342	922	6,973	447	81,642	17.9	7.6	42.6
Vernon.....	150,339	43,359	7,971	1,693	6,227	51	99,009	28.8	5.3	18.4
Washington.....	227,279	65,498	21,301	6,333	14,260	708	140,480	28.8	9.4	32.5
Weber.....	33,013	4,369	1,104	2,870	3,395	20,001	57.5	7.6	13.2	40.9
West Baton Rouge.....	57,363	39,147	2,369	1,089	2,923	152	37,691	32.9	3.5	10.6
West Carroll.....	145,560	45,903	18,560	4,322	13,972	266	81,497	31.3	12.8	40.9
West Feliciana.....	180,763	32,174	14,258	3,569	9,261	1,488	134,331	17.8	7.9	44.3
Total.....	10,439,481	3,613,542	1,348,064	479,152	677,964	191,548	5,477,275	34.6	12.9	37.3

a See table of counties reporting an excessive acreage in pasture, on page 13.

MASSACHUSETTS.

Harford.....	247,146	99,410	58,446	40,481	7,931	10,034	89,290	40.2	23.6	58.8
Howard.....	193,032	69,686	21,573	14,903	3,475	3,195	57,793	46.8	14.5	31.0
Kent.....	172,823	93,532	33,852	25,551	3,471	5,439	45,439	51.1	19.6	36.2
Montgomery.....	273,270	123,042	55,383	41,357	5,930	5,096	94,845	45.0	20.3	45.0
Prince Georges.....	240,036	59,469	41,853	25,093	14,149	13,714	138,714	21.8	17.4	70.4
Queen Annes.....	219,072	104,912	36,739	30,338	2,903	3,498	77,421	48.0	16.8	35.0
St. Marys.....	146,270	44,626	40,782	19,443	16,490	4,849	107,379	23.1	21.2	91.4
Somerset.....	146,270	42,484	10,934	2,922	2,527	5,485	59,852	29.0	7.5	25.7
Talbot.....	163,038	79,771	23,643	19,533	1,258	2,852	59,624	48.9	14.5	29.6
Washington.....	231,191	141,387	34,535	20,531	11,046	2,358	55,269	61.2	14.9	24.4
Wicomico.....	197,821	66,049	11,835	6,713	2,215	2,907	119,937	33.4	6.0	17.9
Worcester.....	234,525	70,863	27,757	14,723	3,298	9,766	135,905	30.2	11.8	39.2
Total.....	5,037,140	2,006,078	859,209	496,033	233,925	129,251	2,191,853	39.7	17.0	42.8

Barnstable.....	49,798	8,931	10,873	5,591	3,091	2,191	29,994	17.9	21.8	121.7
Bertshire.....	388,353	99,408	132,279	22,577	70,374	39,328	106,666	25.0	34.1	133.1
Bristol.....	190,285	45,188	36,978	7,065	16,315	12,998	108,119	23.7	19.4	81.8
Dukes.....	129,209	1,970	7,934	3,707	1,053	3,780	9,305	10.3	41.3	402.7
Essex.....	171,893	58,779	52,334	10,112	27,144	15,078	60,780	34.2	30.4	89.0
Franklin.....	314,700	68,455	134,446	9,369	79,886	45,191	111,799	21.8	42.7	196.4
Hampden.....	253,398	57,238	89,274	15,628	44,304	29,342	106,886	22.6	35.2	156.0
Hampshire.....	276,054	66,708	101,067	13,566	53,075	34,420	108,279	24.2	36.6	151.5
Middlesex.....	349,634	97,046	79,554	17,436	41,528	20,590	173,034	27.8	22.8	82.0
Nantucket.....	3,109	632	1,142	199	38	905	1,335	20.3	36.7	180.7
Norfolk.....	104,042	26,341	23,535	6,190	13,049	4,297	54,165	25.3	22.6	89.4
Plymouth.....	136,915	28,445	19,842	7,001	8,948	3,893	88,615	20.8	14.5	69.7
Suffolk.....	3,435	2,223	998	411	8,368	219	214	64.7	29.1	44.9
Worcester.....	615,116	147,385	236,501	31,546	116,737	88,158	231,230	24.0	38.4	160.5
Total.....	2,875,941	708,762	926,758	150,392	475,970	300,396	1,240,421	24.6	32.2	130.8

MICHIGAN.

Alcona.....	104,732	24,023	44,009	3,627	11,918	28,464	36,700	22.9	42.0	183.2
Alcona.....	29,539	3,598	1,522	301	999	33,223	24,419	12.2	5.2	42.3
Alcona.....	472,708	236,375	115,136	38,008	43,846	8,371	121,197	50.0	24.4	48.7
Alcona.....	177,976	35,626	41,955	4,403	29,787	8,310	70,395	24.1	28.4	117.8
Antrim.....	145,430	48,235	36,188	5,682	25,188	5,318	61,007	33.2	24.9	75.0
Arenac.....	114,176	36,106	45,739	3,902	34,655	7,142	32,331	31.6	40.1	126.7
Baraga.....	34,844	7,206	3,315	541	2,501	273	24,323	20.7	9.5	46.0
Barry.....	336,836	155,487	84,473	31,783	32,075	20,615	96,876	46.2	25.1	54.3
Bay.....	213,222	101,669	67,900	14,735	38,284	14,881	43,653	47.7	31.8	66.8
Benzie.....	98,588	33,516	32,797	4,011	23,021	5,765	32,275	34.0	33.3	97.9

TABLE II.—*Pasture land on farms in the United States, by counties (1910 census)*—Continued.

County.	Total land in farms.	Land in crops.	Pasture land.				All other farm land.	Percentage of total farm land de- voted to—		Acres in pasture per 100 acres in crops.
			Total.			Other.		Crops.	Pasture.	
			Total.	Improved.	Woodland.					

MICHIGAN—Continued.										
Berrien.....	333,326	194,409	61,184	19,058	28,365	13,761	77,133	58.3	18.4	31.5
Branch.....	306,489	157,757	84,250	19,196	25,486	39,568	64,452	51.5	27.5	53.4
Calhoun.....	411,801	203,236	104,012	33,673	31,905	39,534	104,553	49.4	25.3	51.2
Cass.....	295,435	147,133	60,919	24,063	22,334	13,922	87,383	49.8	20.6	41.4
Charlevoix.....	127,625	38,643	39,517	6,186	19,896	13,465	49,465	30.3	31.0	102.3
Cheboygan.....	120,418	32,257	33,870	5,383	17,837	10,650	54,291	26.8	28.1	105.0
Chippewa.....	176,227	60,311	38,588	7,562	27,797	3,229	77,338	34.2	21.9	64.0
Clare.....	164,905	32,647	89,418	3,498	56,947	25,673	46,840	19.8	51.8	261.6
Clinton.....	351,640	184,530	84,385	28,684	33,257	22,414	82,725	52.5	24.0	45.7
Crawford.....	46,610	7,597	17,850	311	16,737	802	21,163	16.3	38.3	235.0
Delta.....	112,811	35,038	34,211	5,875	20,413	7,923	43,562	31.1	30.3	97.6
Dickinson.....	23,480	6,221	6,421	432	4,993	1,266	10,945	25.2	28.2	112.0
Eaton.....	345,853	180,070	102,895	26,490	38,559	37,446	62,888	52.1	29.8	57.1
Emmet.....	124,972	34,455	39,800	6,303	25,347	8,150	50,717	27.6	31.8	115.5
Genesee.....	388,476	221,820	94,175	28,194	44,353	24,628	72,481	57.1	24.2	42.5
Gladwin.....	128,598	34,454	42,692	5,332	20,380	16,980	51,452	26.8	33.2	123.9
Gogebie.....	13,119	4,084	4,005	311	1,042	3,253	4,429	31.1	35.1	112.8
Grand Traverse.....	176,651	75,892	37,347	9,488	22,978	4,881	63,412	43.0	21.1	49.2
Gratiot.....	333,148	171,185	96,114	20,020	46,532	29,572	65,849	51.4	28.9	56.1
Hillsdale.....	192,620	101,614	102,446	37,161	38,671	26,614	78,570	51.4	27.5	53.5
Houghton.....	96,857	28,517	12,449	1,624	6,217	4,608	52,891	30.4	18.3	43.7
Huron.....	471,995	235,327	135,634	38,747	59,092	37,885	101,034	49.9	28.7	57.6
Ingham.....	333,095	167,731	92,381	23,278	32,535	36,568	72,983	50.4	27.7	55.1
Ionia.....	351,505	180,874	87,237	27,398	35,081	24,758	83,394	51.5	24.8	48.2
Iosco.....	112,710	26,691	45,349	3,170	19,280	22,899	40,760	23.7	40.2	170.3
Iron.....	29,368	6,966	2,908	795	1,764	349	19,494	23.7	9.9	41.7
Isabella.....	298,099	132,016	101,877	15,935	46,515	39,427	64,266	44.3	34.2	77.2
Jackson.....	422,507	202,291	101,916	30,854	30,506	40,556	118,300	47.9	24.1	50.4
Kalamazoo.....	331,014	173,680	63,411	28,085	19,631	21,695	88,523	52.3	21.0	40.1
Kalkaska.....	80,501	27,993	21,135	2,852	11,378	6,905	31,373	34.8	25.3	75.5
Kent.....	486,043	233,496	158,400	71,875	55,865	30,000	94,147	48.0	32.6	67.8
Keweenaw.....	2,731	690	5	5	225	400	1,433	22.3	25.3	113.5
Lake.....	87,730	19,654	28,758	3,831	18,754	6,173	39,318	22.4	32.8	146.3
Lapeer.....	400,452	194,242	120,759	31,289	50,001	39,463	85,451	48.5	30.2	62.2
Lecanau.....	139,303	56,602	45,754	10,072	29,592	6,000	56,947	35.5	28.7	80.8
Lenawee.....	492,032	262,204	132,473	59,006	52,770	29,697	64,355	56.8	29.3	51.7

Livingston.....	162,209	94,889	26,256	33,514	35,099	91,997	46.5	27.2	58.5
Luce.....	20,732	2,175	331	1,350	494	13,360	25.1	10.5	41.9
MacInac.....	58,189	13,871	6,968	4,327	612	37,350	25.8	12.0	50.2
Macomb.....	286,503	66,760	19,665	31,770	15,325	49,578	59.4	23.3	39.2
Manistee.....	52,599	48,926	5,786	20,210	13,930	43,408	36.3	33.7	93.0
Marquette.....	67,806	20,945	3,280	13,449	4,216	39,057	11.5	30.9	208.4
Mason.....	72,388	57,793	7,676	25,605	24,512	41,114	42.3	33.7	79.8
Mecosta.....	101,608	102,016	17,184	34,559	50,273	82,157	35.6	35.7	100.4
Menominee.....	167,443	43,932	9,340	42,810	20,608	50,753	26.2	43.5	165.6
Midland.....	176,626	69,889	8,751	25,547	38,593	46,147	33.7	40.1	119.0
Missaukee.....	137,355	59,588	7,507	26,210	11,841	55,221	27.9	34.8	125.0
Monroe.....	332,245	207,145	26,282	31,907	11,691	55,221	62.3	21.0	33.7
Montcalm.....	392,870	174,487	28,970	54,902	30,451	95,060	44.4	26.7	70.7
Montmorency.....	55,715	14,892	2,635	6,676	6,181	30,298	18.9	21.1	141.5
Muskegon.....	185,010	69,898	14,391	39,355	15,180	50,781	37.7	34.8	92.2
Newaygo.....	325,721	101,242	12,085	73,195	30,772	106,427	31.1	36.2	116.6
Oakland.....	260,367	118,629	44,019	44,568	30,042	103,246	48.0	21.9	45.6
Ocean.....	243,642	68,584	13,755	37,996	16,833	76,595	40.4	28.1	69.6
Ogemaw.....	144,628	60,790	6,112	34,062	20,016	48,958	24.1	42.0	174.3
Ontonagon.....	7,937	8,193	3,359	3,965	3,869	21,943	20.8	21.5	103.2
Oshtemo.....	248,477	92,880	11,984	40,693	40,203	74,641	32.6	37.4	114.7
Oscoda.....	59,924	16,964	1,974	12,689	3,301	34,780	13.6	28.3	207.6
Oshtemo.....	39,559	18,076	1,831	12,695	3,000	26,657	30.3	24.9	82.0
Ottawa.....	167,996	96,465	30,329	39,195	26,941	59,668	51.8	29.8	57.4
Presque Isle.....	28,475	42,819	3,939	21,235	17,182	60,225	21.7	32.6	150.4
Roscommon.....	33,907	4,783	839	21,698	17,182	24,660	14.1	13.2	98.3
Saginaw.....	430,230	215,117	25,918	65,089	30,733	96,373	50.9	28.3	56.6
St. Clair.....	414,574	224,737	41,403	84,418	29,667	34,329	54.2	37.1	69.2
St. Joseph.....	300,624	156,093	24,381	14,385	19,191	86,574	51.9	19.3	37.1
Sault Ste. Marie.....	531,321	297,442	160,907	69,073	43,756	92,972	54.0	29.2	54.1
Schoolcraft.....	45,455	10,351	802	2,897	590	30,755	22.8	9.6	42.0
Shiawassee.....	327,064	183,612	76,563	27,578	23,624	66,889	56.1	23.4	41.7
Tuscola.....	450,219	220,423	36,927	68,864	29,483	94,522	49.0	30.0	61.4
Van Buren.....	361,570	185,268	32,051	34,661	14,892	103,098	51.2	20.1	39.2
Washtenaw.....	497,026	224,238	42,117	35,710	31,783	93,178	52.5	25.7	48.9
Wayne.....	316,216	79,029	32,580	34,565	11,884	62,793	55.2	25.0	45.3
Wexford.....	147,585	51,284	8,472	25,355	11,757	50,737	34.7	30.9	88.8
Total.....	18,940,614	8,589,899	1,362,743	2,424,930	1,546,078	5,016,964	45.4	28.2	62.1

MINNESOTA.

Atkin.....	175,796	20,041	72,985	49,401	17,532	82,770	11.4	41.5	394.2
Anoka.....	203,097	71,942	6,021	46,022	12,054	97,058	35.4	31.6	89.1
Becker.....	354,965	143,065	15,390	60,073	19,947	96,580	40.3	29.3	80.7
Beltrami.....	223,764	20,620	5,839	50,294	5,839	145,233	9.2	25.9	290.8
Benton.....	195,187	88,145	4,775	51,759	13,975	36,933	43.2	53.9	79.5
Bigstone.....	282,959	183,221	36,500	2,749	12,541	63,238	64.7	12.9	19.9
Blue Earth.....	448,885	279,663	39,375	35,582	29,356	64,909	62.3	23.2	37.3

TABLE II.—*Pasture land on farms in the United States, by counties (1910 census)*—Continued.

County.	Total land in farms.	Land in crops.	Pasture land.				All other farm land.	Percentage of total farm land de- voted to—		Acres in pasture per 100 acres in crops.	
			Total.		Improved.	Woodland.		Other.	Crops.		Pasture.
MINNESOTA—Continued.											
Brown.....	365,311	214,859	68,765	36,486	11,272	21,007	81,687	58.8	18.8	32.0	
Carlton.....	120,505	20,439	42,894	2,323	31,790	8,781	57,172	17.0	35.6	209.9	
Carver.....	216,391	117,102	83,660	4,729	51,678	27,253	13,629	54.1	38.7	71.4	
Cass.....	147,081	21,445	47,284	1,688	41,137	4,439	78,352	66.3	32.1	220.5	
Chippewa.....	341,736	226,476	50,565	28,793	5,239	16,533	64,695	14.6	14.8	22.3	
Chicago.....	225,773	86,480	104,123	4,895	85,950	13,278	35,170	38.3	46.1	120.4	
Clay.....	531,422	348,501	72,326	35,937	16,837	19,552	110,595	65.6	13.6	20.8	
Clearwater.....	174,616	30,978	64,920	1,539	47,065	15,716	78,718	17.7	37.2	209.6	
Cook.....	23,769	1,111	995	78	917	.....	21,663	4.7	4.2	89.6	
Cottonwood.....	371,496	226,092	67,530	48,056	4,630	14,844	77,874	60.9	18.2	29.9	
Crow Wing.....	168,771	39,257	69,097	3,068	55,850	10,179	60,417	23.3	40.9	176.0	
Dakota.....	329,801	214,633	69,273	23,226	29,727	16,320	45,895	55.1	21.0	32.3	
Dodge.....	261,863	146,123	68,944	41,483	11,304	16,157	46,796	65.8	26.3	47.2	
Douglas.....	354,379	178,278	104,466	19,912	60,200	24,354	71,635	50.3	29.5	58.6	
Faribault.....	433,481	276,288	83,407	47,322	12,073	24,051	73,786	63.7	19.2	30.2	
Filmore.....	518,814	266,099	64,025	24,448	29,150	10,127	188,690	51.3	12.3	24.1	
Freeborn.....	413,711	248,340	114,139	47,123	23,587	42,449	51,212	60.0	27.6	46.0	
Goodhue.....	462,052	276,872	100,533	38,887	39,399	22,247	84,647	59.9	21.8	36.3	
Grant.....	296,434	190,451	45,613	33,057	3,774	8,782	60,420	64.2	15.4	23.9	
Hennepin.....	284,378	156,784	81,732	12,305	50,625	18,802	45,862	35.1	28.7	52.1	
Houston.....	327,094	129,313	150,807	18,853	119,002	12,952	46,974	39.5	46.1	116.6	
Hubbard.....	151,984	38,760	47,912	3,742	38,721	5,449	65,312	25.5	31.5	123.6	
Isanti.....	237,642	88,509	79,937	5,208	59,050	15,699	69,176	37.3	33.7	90.3	
Itasca.....	108,380	7,580	27,056	1,496	23,639	1,921	73,744	7.0	25.0	356.9	
Jackson.....	252,292	252,292	76,840	54,943	4,543	17,354	82,207	61.3	18.7	30.5	
Kanabec.....	116,370	29,053	55,790	2,937	27,348	25,514	31,518	25.0	47.9	192.1	
Kandiyohi.....	463,345	276,127	92,903	43,856	16,103	32,944	94,315	59.6	20.1	33.6	
Kittson.....	372,066	224,285	55,628	15,791	22,815	17,022	92,153	60.3	14.9	24.8	
Koochiching.....	73,245	3,147	11,888	13,640	10,107	1,141	58,210	4.3	16.2	377.8	
Lac Qui Parle.....	464,102	318,910	59,983	31,908	4,446	23,629	8,269	68.7	12.9	18.8	
Lake.....	22,279	1,412	12,216	294	10,599	1,323	8,651	6.3	54.8	865.2	
Lesueur.....	261,945	146,868	78,305	14,938	33,958	29,409	36,772	56.1	23.9	53.3	
Lincoln.....	306,129	164,793	48,940	27,233	1,969	19,718	92,386	53.8	16.0	29.7	
Lyon.....	401,546	233,843	73,298	43,826	5,990	23,482	94,405	58.2	18.3	31.4	
McLeod.....	298,961	180,444	74,413	25,374	21,280	27,759	44,104	60.3	24.9	41.2	

	41,995	16,600	4,542	1,509	1,850	1,183	20,844	39.5	10.8	27.2
Mahmoud.....	567,865	290,243	114,035	26,447	52,454	35,434	163,587	51.1	20.1	39.3
Marshall.....	427,727	270,802	82,008	47,792	5,714	28,472	74,917	63.3	19.2	30.3
Martin.....	358,423	218,293	84,036	29,987	30,072	23,977	56,094	60.9	23.7	38.5
Meeker.....	123,647	39,100	54,028	3,824	28,962	21,242	30,450	31.7	43.7	138.0
Millicates.....	374,738	155,583	114,349	a 8,893	a 74,156	a 31,390	104,796	41.5	30.5	73.5
Morrison.....	428,428	203,038	73,328	48,063	13,329	11,936	32,062	61.4	17.1	27.9
Mower.....	401,048	238,035	79,543	60,188	3,363	16,992	83,470	59.4	19.8	33.4
Murray.....	282,212	164,115	56,039	20,513	13,724	17,520	42,038	66.2	21.4	34.2
Nicollet.....	418,200	276,913	89,422	68,932	2,695	17,775	51,865	62.6	21.4	32.3
Nobles.....	438,534	251,908	68,666	29,275	21,080	18,311	97,900	60.2	16.4	47.2
Norman.....	333,620	219,332	97,716	41,806	35,121	20,789	76,572	55.7	24.8	44.6
Omsted.....	996,535	477,965	279,349	46,673	178,866	53,810	239,221	43.0	28.0	58.4
Ottertail.....	237,485	112,450	57,847	10,107	25,554	22,186	48,718	48.7	22.5	51.5
Pennington.....	49,685	49,685	108,048	4,621	77,634	25,793	72,956	21.5	46.8	217.5
Pine.....	177,181	88,313	52,066	37,007	3,321	11,738	38,742	66.1	19.4	29.4
Pipestone.....	267,989	133,204	66,488	59,439	80,319	40,767	209,994	56.1	20.3	36.2
Polk.....	373,852	213,680	180,545	18,653	10,595	37,240	93,126	57.2	17.8	31.1
Pope.....	60,543	32,673	13,572	3,254	8,425	1,893	14,298	54.0	22.1	41.5
Ramsey.....	125,402	60,538	27,667	7,753	11,387	8,327	37,197	48.3	22.1	43.7
Red Lake.....	527,471	304,300	90,430	45,277	7,926	37,227	132,741	57.7	17.1	29.7
Redwood.....	589,798	377,824	88,915	44,589	10,386	33,970	123,029	64.1	13.1	23.5
Renville.....	237,944	179,083	73,275	23,353	21,940	29,982	43,586	60.1	25.3	42.0
Rice.....	288,351	204,426	56,255	42,678	2,677	10,900	27,670	70.9	19.5	27.5
Rock.....	315,106	97,475	79,549	9,398	40,594	29,557	138,082	30.9	25.2	81.6
Roseau.....	272,945	29,486	76,899	2,984	66,620	7,295	166,610	10.8	28.2	260.8
St. Louis.....	207,884	109,044	69,948	7,498	45,805	16,645	28,892	52.5	33.6	64.2
Scott.....	204,537	87,928	78,285	6,893	64,640	6,752	38,324	43.0	38.3	89.0
Sherburne.....	204,537	223,436	87,044	27,349	20,919	38,776	46,755	62.5	24.4	39.0
Sibley.....	761,242	387,797	a 254,608	a 41,120	a 139,869	a 73,619	118,837	50.9	33.4	65.6
Stearns.....	292,555	162,638	61,524	32,650	11,234	17,640	38,393	61.9	23.4	37.8
Stevens.....	304,926	197,515	41,402	27,320	1,570	12,512	66,009	64.8	13.6	21.0
Swift.....	408,661	255,144	61,955	38,764	2,821	20,370	91,562	62.4	15.2	24.3
Todd.....	424,221	160,640	169,759	12,012	126,790	30,357	93,822	37.9	40.0	105.7
Traverse.....	317,557	218,329	34,593	26,726	3,068	4,799	64,635	68.7	10.9	15.8
Wabasha.....	320,894	176,732	81,758	23,063	45,107	13,888	62,404	55.1	25.5	46.3
Wadena.....	158,666	58,338	64,391	5,958	40,912	17,191	36,177	36.8	40.4	109.7
Waseca.....	256,347	162,211	56,646	20,552	14,427	21,667	37,490	63.3	22.1	34.9
Washington.....	123,168	67,672	12,870	12,870	41,273	13,529	35,472	54.4	29.9	54.9
Watsonwan.....	231,664	154,572	52,632	36,545	4,844	11,249	44,454	61.4	20.9	34.0
Wilkin.....	335,986	231,505	35,049	29,114	1,934	4,901	69,432	68.9	10.4	15.1
Winona.....	182,243	131,045	37,041	25,928	88,539	17,178	60,346	48.7	35.2	72.3
Wright.....	399,328	193,718	137,887	14,761	85,900	37,226	67,723	48.5	34.5	71.2
Yellow Medicine.....	451,719	285,568	62,687	33,245	7,529	21,913	103,464	63.2	13.9	21.9
Total.....	27,675,823	14,778,337	6,591,439	2,006,150	2,905,559	1,679,730	6,306,047	53.4	23.8	44.6

a Estimated.

TABLE II.—*Pasture land on farms in the United States, by counties (1910 census)*—Continued.

County.	Total land in farms.	Land in crops.	Pasture land.			All other farm land.	Percentage of total farm land de- voted to—		Acres in pasture per 100 acres in crops.
			Improved.		Woodland.		Crops.	Pasture.	
			Total.	Other.					
MISSISSIPPI.									
Adams.....	151,494	45,984	46,166	11,285	28,566	6,315	69,344	28.5	100.4
Alcorn.....	212,295	52,690	47,060	10,914	30,529	5,617	112,545	24.8	89.3
Amite.....	306,825	93,372	60,405	15,960	41,344	3,101	153,018	30.4	64.7
Attala.....	401,298	119,067	81,880	18,660	49,895	13,325	200,351	29.7	68.7
Benton.....	208,617	47,226	52,721	8,543	33,785	10,393	108,670	22.6	111.7
Bolivar.....	328,085	203,714	18,341	1,479	15,431	12,431	116,030	62.1	4.1
Calhoun.....	252,094	65,531	70,752	13,847	41,851	15,054	145,811	23.2	108.0
Carroll.....	318,436	107,228	63,927	18,313	40,723	10,891	141,281	33.7	65.2
Chickasaw.....	244,075	89,556	63,629	14,443	31,614	17,572	90,910	36.7	71.1
Choctaw.....	237,768	58,643	47,475	14,569	25,759	7,147	131,650	24.7	81.0
Claborne.....	224,180	69,829	53,529	19,647	27,285	6,597	100,822	31.2	76.7
Clarke.....	249,739	63,244	17,534	4,334	11,926	1,274	168,961	25.3	27.7
Clay.....	220,976	91,782	51,421	21,970	26,876	2,575	77,773	41.5	56.0
Columbia.....	211,387	128,662	17,515	767	16,580	168	65,210	30.8	13.6
Copiah.....	383,265	118,004	92,394	34,001	49,791	8,512	172,867	30.8	78.3
Covington.....	139,661	43,096	6,899	913	5,549	437	109,669	27.0	16.0
De Soto.....	269,557	116,650	75,949	18,454	39,867	17,628	76,928	43.3	65.1
Forrest.....	81,170	18,060	3,717	194	3,370	153	59,363	22.3	20.5
Franklin.....	221,417	54,423	39,271	14,579	18,692	6,000	127,753	24.6	72.2
George.....	51,467	6,423	7,771	46	7,352	352	37,573	11.9	126.9
Greene.....	110,280	7,944	3,725	252	2,713	730	98,621	7.2	46.9
Grenada.....	203,115	67,714	54,132	11,607	34,050	8,475	81,269	33.3	79.9
Hancock.....	34,141	3,650	2,174	410	1,744	20	28,917	6.4	71.3
Harrison.....	117,849	12,614	15,171	802	12,626	1,743	90,034	10.7	120.0
Hinds.....	388,680	181,361	80,071	30,194	40,400	9,480	127,245	46.7	44.1
Holmes.....	381,302	167,282	58,681	10,703	37,713	10,265	155,339	43.9	35.1
Issaquena.....	78,246	45,652	1,447	791	403	253	31,147	58.3	3.2
Ivawamba.....	275,660	65,758	56,246	11,317	39,930	4,900	153,626	23.9	85.5
Jackson.....	86,109	8,134	57,563	215	55,115	2,203	20,412	9.4	707.7
Jasper.....	289,387	71,523	53,789	13,553	33,889	6,367	164,075	24.7	75.3
Jefferson.....	224,095	67,053	49,878	18,898	26,740	4,240	107,164	23.9	74.4
Jefferson Davis.....	137,588	52,675	45,723	3,096	12,570	57	89,190	33.1	29.8
Jones.....	224,881	56,188	11,767	800	13,650	257	153,926	35.0	26.3
Kemper.....	318,795	99,429	76,874	25,644	45,519	5,711	142,752	31.1	77.5

Lafayette.....	317, 785	91, 209	91, 517	17, 529	55, 608	18, 380	165, 059	26.2	26.3	100.3
Lamar.....	68, 458	14, 368	2, 804	90	1, 919	795	51, 286	21.0	4.1	19.5
Lauderdale.....	298, 123	91, 051	71, 771	19, 695	49, 476	2, 600	132, 601	31.5	24.1	76.3
Lawrence.....	153, 364	42, 621	14, 827	3, 675	9, 202	1, 950	95, 916	27.8	9.7	34.8
Leake.....	288, 254	78, 502	47, 358	16, 499	27, 341	3, 518	162, 394	27.2	16.4	60.3
Lee.....	259, 850	110, 144	51, 073	21, 633	19, 360	10, 080	98, 633	42.4	19.7	46.4
Leflore.....	228, 312	136, 956	31, 297	801	4, 671	25, 822	60, 059	62.0	13.7	52.8
Lincoln.....	271, 858	83, 603	46, 777	8, 882	36, 704	1, 101	141, 478	30.7	17.2	66.0
Lowndes.....	241, 833	114, 159	34, 210	11, 247	18, 273	4, 690	94, 153	47.3	14.2	30.0
Madison.....	369, 075	151, 945	62, 568	29, 209	28, 406	4, 953	154, 562	41.2	17.0	41.2
Marshall.....	167, 972	40, 922	8, 419	1, 174	6, 911	4	118, 631	24.4	5.0	20.6
Monroe.....	350, 901	122, 507	95, 865	17, 897	44, 763	33, 205	132, 529	34.9	27.3	78.3
Montgomery.....	213, 962	94, 901	59, 847	14, 034	41, 959	3, 854	176, 916	40.0	15.2	37.9
Neshoba.....	253, 786	69, 731	52, 985	12, 851	27, 364	9, 051	99, 792	30.3	23.0	75.9
Newton.....	288, 821	81, 364	52, 997	14, 973	34, 949	5, 043	131, 050	29.5	20.9	76.0
Noxubee.....	243, 473	143, 755	43, 253	20, 910	19, 190	3, 153	101, 465	50.5	15.2	62.8
Oktibbeha.....	232, 064	67, 631	49, 390	21, 716	25, 970	1, 704	115, 043	29.1	21.3	73.0
Panola.....	340, 878	111, 371	72, 135	12, 145	34, 953	25, 037	127, 372	51.0	21.2	51.0
Pearl River.....	83, 476	12, 519	33, 545	488	32, 111	946	37, 392	15.0	40.2	267.9
Perry.....	83, 568	12, 416	8, 996	995	7, 676	825	62, 156	14.9	10.8	72.4
Pike.....	298, 637	90, 820	38, 961	7, 030	27, 181	4, 750	168, 856	30.4	23.0	42.9
Pontotoc.....	267, 821	77, 746	57, 718	21, 557	33, 620	12, 541	122, 357	29.0	25.3	87.1
Prentiss.....	293, 897	69, 948	55, 470	8, 916	38, 401	8, 123	108, 179	29.9	23.7	79.3
Quitman.....	91, 986	48, 332	9, 955	74	630	251	42, 699	52.5	1.0	2.0
Rankin.....	354, 858	82, 796	78, 590	33, 615	41, 327	3, 645	193, 472	23.3	22.1	94.9
Scott.....	216, 121	53, 906	41, 759	14, 627	25, 835	1, 297	120, 456	24.9	19.3	77.5
Sharkey.....	107, 088	68, 363	610	101	28, 782	1, 175	38, 085	63.9	0.6	0.9
Smith.....	195, 217	60, 490	33, 621	3, 372	17, 198	2, 628	151, 351	31.0	17.2	55.6
Sunflower.....	238, 914	61, 639	25, 924	6, 098	17, 198	2, 628	151, 351	25.8	10.9	42.1
Tallahatchie.....	224, 167	120, 692	9, 420	1, 411	7, 589	420	94, 055	53.8	4.2	7.8
Tate.....	235, 716	111, 824	37, 885	4, 564	24, 352	8, 969	86, 007	47.4	16.1	33.9
Tippah.....	212, 821	94, 419	55, 305	18, 781	25, 360	11, 164	63, 097	44.4	26.0	58.6
Tishomingo.....	259, 425	55, 856	59, 724	14, 537	29, 813	15, 374	143, 845	21.5	23.0	106.9
Tunica.....	196, 843	40, 585	196, 843	3, 417	9, 215	1, 418	142, 168	20.6	7.2	84.7
Union.....	152, 014	91, 100	19, 519	1, 015	17, 619	1, 884	11, 395	59.9	12.8	21.4
Warren.....	226, 617	75, 941	50, 200	11, 544	25, 626	10, 030	100, 476	33.5	22.2	66.1
Washington.....	211, 517	51, 063	65, 098	12, 050	39, 016	13, 432	95, 356	24.1	30.8	127.5
Wayne.....	309, 492	122, 265	8, 295	2, 160	4, 588	1, 577	178, 932	39.5	2.7	6.8
Webster.....	185, 472	35, 658	9, 258	899	7, 429	960	139, 556	19.8	5.0	25.3
Wilkinson.....	238, 899	62, 451	65, 462	13, 841	46, 584	5, 037	110, 986	26.1	104.8	104.8
Winston.....	235, 131	66, 623	45, 183	12, 100	27, 881	5, 202	123, 345	28.3	19.2	68.2
Yalobusha.....	277, 220	68, 082	47, 502	16, 747	28, 268	2, 487	101, 636	24.6	17.1	69.8
Yazoo.....	239, 547	77, 262	63, 219	17, 467	35, 117	10, 635	119, 066	29.8	24.4	81.8
442, 824	194, 656	62, 898	22, 943	36, 549	3, 436	185, 270	44.0	14.2	32.3	
Total.....	18, 557, 533	6, 218, 052	3, 392, 156	882, 199	2, 026, 533	483, 424	8, 947, 325	33.5	18.3	54.6

TABLE II.—*Pasture land on farms in the United States, by counties (1910 census)*—Continued.

County.	Total land in farms.	Land in crops.	Pasture land.				All other farm land.	Percentage of total farm land devoted to—		Acres in pasture per 100 acres in crops.
			Total.			Other.		Crops.	Pasture.	
			Total.	Improved.	Woodland.					
MISSOURI.										
Adair.....	321,073	134,796	138,110	79,062	54,337	4,711	48,167	42.0	43.0	102.5
Andrew.....	263,294	139,128	103,218	60,544	37,815	4,859	20,948	52.8	39.2	74.2
Atchison.....	313,943	202,109	78,490	61,690	11,104	2,696	33,344	64.4	25.0	38.8
Arche.....	426,560	251,504	140,239	102,689	35,069	2,481	34,807	59.0	32.9	55.8
Audrain.....	349,165	136,237	95,568	42,274	47,036	6,258	117,360	39.0	27.4	70.1
Barry.....	336,780	193,954	84,083	62,018	15,241	6,824	58,743	57.6	25.0	43.4
Barton.....	517,021	278,091	137,056	108,481	37,270	11,305	81,874	53.8	30.4	56.5
Bates.....	391,635	131,770	166,137	49,356	101,323	15,458	93,728	33.6	42.4	126.0
Benton.....	83,800	42,468	19,567	16,756	16,756	6,143	171,000	28.2	11.3	50.7
Bollinger.....	158,159	70,351	76,803	39,566	37,603	4,473	76,636	42.5	38.7	91.2
Boone.....	173,441	131,702	76,077	32,008	17,474	2,257	29,155	55.6	31.1	57.8
Buchanan.....	236,934	131,702	76,077	32,008	17,474	2,257	115,162	27.1	11.7	43.1
Butler.....	188,269	51,086	22,021	4,290	22,935	2,171	25,039	50.6	40.1	79.4
Caldwell.....	269,183	136,097	108,027	82,921	25,935	18,448	81,448	40.0	43.3	108.4
Callaway.....	489,240	195,717	212,075	100,148	93,479	5,226	145,207	21.6	30.3	140.2
Camden.....	301,616	65,128	91,281	13,420	72,635	8,245	137,920	42.1	19.1	45.5
Cape Girardeau.....	329,867	138,995	62,952	32,346	22,361	8,245	43,568	67.1	32.2	56.3
Carroll.....	416,514	237,752	133,989	93,525	26,562	7,902	41,743	57.1	28.8	128.3
Carter.....	89,316	19,994	25,754	1,166	17,397	7,191	43,568	22.4	33.4	59.0
Cass.....	425,128	238,925	142,094	99,006	34,287	8,801	44,109	56.2	33.4	86.9
Cedar.....	289,176	120,303	103,459	45,097	46,520	11,842	65,414	41.6	35.8	51.7
Chariton.....	412,719	204,703	167,666	105,702	51,299	10,665	70,350	46.2	37.9	76.1
Christian.....	359,226	95,591	73,328	38,276	25,651	9,401	90,307	36.9	28.3	84.7
Clark.....	335,912	135,059	113,593	51,905	55,600	6,088	57,260	44.1	37.1	98.3
Clay.....	237,693	107,463	106,023	63,057	29,548	3,418	24,207	45.2	44.6	82.9
Clinton.....	266,702	135,925	111,825	88,982	17,743	5,090	18,952	51.0	41.9	82.9
Cole.....	283,789	80,281	75,387	18,848	45,831	10,708	68,118	35.9	33.7	58.7
Cooper.....	340,199	182,545	107,120	55,358	43,154	8,608	50,534	53.7	31.5	79.1
Crawford.....	281,602	72,107	57,085	16,969	29,999	11,017	132,320	23.0	20.3	78.8
Dade.....	302,091	141,146	111,194	57,729	38,047	13,418	49,751	46.7	36.8	92.8
Dallas.....	364,831	89,345	82,875	30,147	48,370	4,358	92,611	33.7	31.3	85.2
Davies.....	312,530	153,327	130,603	71,325	53,277	6,001	58,600	44.8	35.3	64.5
Dekalb.....	263,469	144,135	92,901	65,426	25,392	2,113	26,433	54.7	13.6	53.2
Dent.....	282,317	72,862	38,763	15,690	21,103	1,970	173,692	25.5	15.9	63.4
Douglas.....	312,022	86,027	54,542	21,552	30,982	2,008	201,453	25.2	7.1	10.8
Dunklin.....	171,456	113,767	12,304	1,932	8,595	1,777	48,385	65.2	7.1	10.8

Franklin.....	476,857	179,301	132,536	44,241	69,571	18,624	165,020	37.6	27.8	73.9
Gasconade.....	297,309	83,805	102,586	15,791	80,408	6,369	110,936	28.2	34.5	122.4
Gentry.....	303,414	139,910	129,119	77,301	44,319	7,499	31,412	46.1	42.6	92.3
Greene.....	285,314	188,196	114,237	59,834	49,698	4,765	82,881	41.9	29.6	60.7
Grundy.....	269,533	113,032	109,626	66,634	37,308	4,684	46,875	48.8	40.7	97.0
Harrison.....	489,393	191,124	189,881	107,949	67,682	17,250	58,588	43.5	43.2	99.3
Henry.....	436,853	238,902	137,919	89,471	38,814	9,634	60,012	54.7	31.6	57.7
Hickory.....	227,733	70,359	91,837	23,439	61,223	10,075	62,537	30.9	41.6	134.8
Holt.....	257,903	146,887	74,511	52,270	16,861	5,380	36,805	56.8	28.9	50.8
Howard.....	267,774	108,722	92,902	43,114	43,844	5,944	66,130	40.6	34.7	83.4
Howell.....	381,570	99,100	85,832	26,691	54,758	4,383	196,638	26.0	22.5	86.6
Iron.....	112,413	29,199	7,834	4,247	7,034	566	71,367	52.8	10.5	40.6
Jackson.....	318,659	168,409	101,085	60,730	35,880	4,475	49,165	56.4	31.7	60.0
Jasper.....	324,200	111,616	182,029	33,517	33,964	14,448	59,179	56.4	25.3	43.8
Jefferson.....	355,272	111,616	132,192	28,296	80,479	23,417	111,464	31.4	37.2	118.4
Johnson.....	488,623	249,281	169,905	117,307	44,093	8,505	69,437	51.0	34.8	68.1
Knox.....	312,371	152,471	116,159	73,344	37,030	5,785	43,741	48.8	37.2	76.2
Laclede.....	333,076	99,398	97,373	32,615	57,449	7,309	136,305	29.8	29.2	98.0
Lafayette.....	368,229	212,720	88,740	66,456	23,932	3,456	61,665	45.9	25.5	41.1
Lawrence.....	336,342	174,108	87,640	63,294	22,960	2,526	93,494	48.9	24.9	51.0
Lewis.....	304,685	134,455	113,107	77,311	32,216	18,086	22,587	44.1	48.5	109.8
Lincoln.....	339,456	159,147	113,107	60,937	44,103	8,067	87,202	44.3	31.5	71.1
Linn.....	376,986	163,391	194,163	127,015	53,963	13,185	19,432	43.3	31.5	118.8
Livingson.....	318,059	133,785	124,805	70,223	45,700	8,882	59,508	42.1	39.2	93.3
McDonald.....	217,189	66,493	56,744	14,533	26,097	16,114	93,952	30.6	26.1	85.3
Madison.....	483,283	202,188	202,126	116,000	73,109	13,017	78,969	41.8	41.8	100.0
Macon.....	138,484	40,981	12,412	4,076	7,591	745	85,091	29.6	9.0	30.3
Marion.....	270,850	71,832	66,193	20,200	38,074	7,919	132,825	26.5	24.4	92.1
Maries.....	257,507	113,424	91,003	39,852	45,557	5,594	53,080	44.0	35.3	80.2
Marion.....	278,794	113,424	120,615	83,272	34,902	2,441	44,184	40.9	43.3	105.8
Mercer.....	323,358	192,878	143,037	27,116	79,874	36,047	89,443	28.5	44.0	154.0
Miller.....	146,955	118,492	7,564	2,339	5,112	113	20,899	80.6	5.1	6.4
Mississippi.....	251,883	119,006	71,920	32,840	30,315	8,765	60,937	47.7	28.6	60.4
Moniteau.....	415,785	185,874	185,887	111,949	53,100	20,838	44,024	44.7	41.7	100.0
Monroe.....	309,196	142,917	102,357	48,175	47,750	6,432	63,922	46.2	33.1	71.6
Montgomery.....	279,822	99,640	96,016	31,173	52,728	12,115	84,166	35.6	34.3	96.4
Morgan.....	156,403	99,576	10,280	1,821	5,940	2,519	46,547	63.7	6.6	10.3
New Madrid.....	304,494	143,638	72,115	27,803	38,326	5,986	88,741	47.2	23.7	50.2
Newton.....	277,104	227,765	72,115	27,803	38,326	5,986	88,741	47.2	23.7	50.2
Nodaway.....	539,919	273,906	24,962	10,088	10,378	4,496	159,690	28.6	9.7	33.8
Oregon.....	258,558	79,822	79,446	13,328	49,024	17,094	166,453	28.7	23.0	81.4
Osage.....	344,721	56,997	38,029	8,255	26,900	2,844	190,336	20.0	13.3	66.7
Ozark.....	285,362	56,997	38,029	8,255	26,900	2,844	190,336	20.0	13.3	66.7
Pemiscot.....	106,956	64,180	1,026	189	828	9	41,780	36.0	1.6	1.6
Perry.....	264,055	95,173	28,152	12,015	12,711	3,426	140,730	36.0	10.7	29.6
Pettis.....	407,360	215,315	135,258	90,480	39,728	5,050	56,757	52.9	33.2	62.8
Phelps.....	279,528	69,700	70,999	22,400	41,881	6,318	139,229	24.9	25.3	101.3
Pike.....	400,122	178,403	156,157	79,716	68,184	8,257	65,562	44.6	39.0	87.5
Platte.....	232,941	128,070	72,187	17,998	52,088	2,101	85,084	53.0	31.0	56.4
Polk.....	369,243	152,152	128,225	55,145	60,370	12,710	88,866	41.2	34.7	84.3

a Estimated.

TABLE II.—*Pasture land on farms in the United States, by counties (1910 census)*—Continued.

County.	Total land in farms.	Land in crops.	Pasture land.				All other farm land.	Percentage of total farm land voted to—		Acres in pasture per 100 acres in crops.
			Total.	Improved.	Woodland.	Other.		Crops.	Pasture.	
MISSOURI—Continued.										
Pulaski.....	214,756	50,775	66,447	19,871	41,648	4,928	97,534	23.6	30.9	130.9
Putnam.....	320,373	128,991	149,811	92,548	51,646	5,617	41,571	40.3	46.8	116.1
Ralls.....	274,441	132,591	109,921	59,119	43,930	6,872	31,929	48.3	40.1	82.9
Randolph.....	285,281	113,790	132,897	67,517	58,673	6,707	38,594	39.9	46.6	116.8
Ray.....	327,341	161,204	122,206	77,549	40,284	4,373	43,931	39.2	37.3	75.8
Reynolds.....	145,551	41,057	18,468	4,617	5,048	8,803	86,026	28.2	12.7	45.0
Ripley.....	191,492	50,723	18,802	5,218	11,897	1,687	121,967	26.5	9.8	37.1
St. Charles.....	312,312	157,374	58,636	30,739	23,569	4,328	96,302	50.4	18.8	37.3
St. Clair.....	374,927	152,692	161,608	58,702	86,160	16,746	60,627	40.7	43.1	105.8
St. Francois.....	182,970	52,880	36,338	11,192	23,658	1,488	93,752	28.9	19.9	68.7
St. Louis.....	247,108	145,053	31,195	8,571	20,210	2,414	70,800	58.7	12.6	21.5
St. Louis City.....	5,075	2,704	306	125	167	14	2,065	53.3	6.0	11.3
Ste. Genevieve.....	238,312	61,754	39,483	13,367	21,465	4,651	137,075	25.9	16.6	63.9
Saline.....	427,016	241,270	123,867	84,739	29,558	9,570	61,879	55.9	29.0	51.3
Schuyler.....	190,290	79,986	89,486	56,978	22,874	9,634	20,818	42.0	47.0	111.9
Scotland.....	270,838	126,795	103,744	62,138	38,925	2,681	40,299	46.8	38.3	81.8
Scott.....	196,336	144,308	12,972	2,672	9,268	1,032	39,056	73.5	9.6	9.0
Shannon.....	189,548	42,401	18,139	4,647	3,711	3,721	129,008	22.4	6.6	42.8
Shelby.....	300,112	145,980	114,133	71,804	32,683	9,646	39,999	48.6	38.0	78.2
Stoddard.....	277,566	138,599	41,336	11,643	28,105	1,588	97,631	49.9	14.9	29.3
Stone.....	189,160	49,191	37,208	20,794	13,849	2,565	102,761	26.0	19.7	75.6
Sullivan.....	388,593	152,034	211,620	150,252	54,385	6,983	34,939	38.1	53.1	133.2
Taney.....	233,800	45,866	40,843	6,289	24,162	10,392	147,091	19.6	17.5	89.0
Texas.....	468,491	128,416	112,839	31,909	67,246	13,684	227,236	27.4	24.1	87.9
Vernon.....	486,494	263,454	145,849	93,144	44,919	7,786	77,191	54.2	30.0	55.4
Warren.....	230,217	82,538	66,894	16,774	32,109	18,011	80,785	35.9	29.1	81.0
Washington.....	217,163	63,487	32,663	9,457	19,606	3,600	121,013	29.2	15.0	51.4
Wayne.....	216,159	58,807	18,570	7,529	9,859	1,122	138,842	27.2	8.6	31.5
Weber.....	300,667	101,350	98,303	41,193	52,568	5,542	100,014	33.7	33.0	98.0
Worth.....	163,802	73,569	70,502	41,372	19,345	9,585	19,791	44.9	43.0	95.9
Wright.....	325,133	91,191	82,688	34,669	43,967	3,452	151,854	28.0	25.2	90.0
Total.....	34,591,248	14,706,471	10,781,515	5,534,034	4,384,280	863,201	9,103,262	42.5	31.2	73.3

MONTANA.

Beaverhead.....	461,315	164,997	224,331	109,903	1,177	113,151	72,087	35,8	48,6	135,9
Broadwater.....	183,887	36,776	103,329	18,301	14,824	70,204	43,782	20,0	56,2	281,0
Carbon.....	286,449	80,480	109,680	17,433	12,124	80,126	96,289	28,1	38,3	136,3
Cascade.....	1,001,534	124,165	754,662	187,373	33,555	533,934	122,707	12,4	75,4	607,8
Chouteau.....	1,690,621	103,953	470,761	107,420	15,459	349,882	425,907	10,4	47,0	452,9
Custer.....	931,581	70,324	575,322	103,666	106,084	365,572	285,735	7,6	61,8	815,8
Dawson.....	607,078	119,060	289,292	147,866	3,367	138,069	207,726	18,1	47,7	262,8
Deer Lodge.....	70,994	19,467	35,878	11,709	1,370	22,769	15,649	27,4	50,5	181,3
Fergus.....	239,445	148,379	495,870	170,234	92,478	233,158	557,582	12,3	41,3	334,2
Flathead.....	75,003	95,795	13,632	13,632	61,155	21,008	68,647	31,3	40,0	127,7
Gallatin.....	139,166	139,166	225,203	44,245	37,930	143,028	167,533	26,2	42,3	161,8
Granite.....	134,437	26,918	78,158	19,307	26,980	31,871	29,731	20,0	58,0	290,4
Jefferson.....	124,437	23,905	64,007	16,335	6,638	41,034	36,525	19,2	51,4	267,8
Lewis and Clark.....	491,278	46,858	358,285	86,206	36,123	235,956	89,135	9,5	72,5	761,6
Lincoln.....	61,036	9,535	15,534	584	6,781	8,169	38,987	14,9	24,2	162,9
Madison.....	421,271	80,139	258,589	53,393	39,892	185,304	82,543	19,0	61,4	322,7
Meagher.....	710,332	60,025	463,790	212,486	22,153	229,151	186,317	8,5	65,3	772,7
Missoula.....	185,294	41,963	59,351	13,106	28,672	17,573	83,980	22,6	32,0	111,4
Park.....	523,317	57,321	364,003	86,106	24,397	254,300	101,993	11,0	69,6	635,0
Powell.....	370,984	51,211	218,589	80,513	28,734	109,342	98,184	14,6	58,9	403,2
Ravalli.....	209,266	76,635	71,760	11,301	39,580	23,879	57,871	36,6	35,7	97,6
Rosebud.....	900,810	38,092	370,207	94,577	85,587	190,043	492,511	4,2	41,1	971,9
Sanders.....	55,917	9,018	31,937	126	18,414	13,397	14,962	16,1	57,1	354,1
Silverbow.....	54,592	8,198	39,134	8,154	12,485	18,495	7,260	15,0	71,7	477,4
Sweet Grass.....	457,715	43,415	362,819	86,751	84,980	191,088	51,481	9,5	79,3	835,7
Teton.....	530,714	50,277	146,548	89,076	9,548	47,924	333,889	9,5	27,6	291,5
Valley.....	576,130	111,710	126,696	39,269	6,618	80,809	337,724	19,4	22,0	113,4
Yellowstone.....	1,215,046	71,535	838,657	71,097	44,912	722,618	304,854	5,9	69,0	1,172,4
Total.....	13,545,603	1,882,725	7,251,087	1,900,159	899,014	4,451,914	4,411,791	13,9	53,5	385,1

NEBRASKA.

Adams.....	346,168	259,486	64,946	25,356	6,699	32,891	21,736	74,9	18,8	25,0
Antelope.....	494,293	303,655	154,828	55,961	20,218	72,649	35,810	61,4	31,3	51,0
Banner.....	317,782	44,061	275,087	31,303	3,460	240,324	(a)	13,9	86,6	624,3
Blaine.....	314,426	57,490	162,787	41,300	57	121,430	94,149	18,3	51,8	283,2
Boone.....	38,240	273,204	110,631	38,494	4,450	67,687	30,465	66,0	26,7	40,5
Boxbutte.....	547,177	80,633	403,922	162,013	120	241,789	62,622	14,7	73,8	500,9
Boyd.....	291,444	156,369	98,795	20,000	21,298	57,497	42,280	51,6	33,9	65,7
Brown.....	518,347	121,473	278,286	23,160	19,095	255,431	113,588	24,4	53,7	220,0
Buffalo.....	576,944	356,958	171,223	47,762	22,337	101,134	48,753	61,9	29,7	48,0
Burt.....	283,669	194,384	69,319	49,714	3,467	10,138	19,904	68,5	24,4	35,7

^a See table of counties reporting an excessive acreage in pasture, on page 13.

Jefferson.....	357, 276	232, 936	104, 975	39, 028	21, 280	44, 607	19, 365	65.2	29.4	45.1
Johnson.....	292, 255	175, 324	55, 282	38, 165	10, 511	6, 606	1, 449	75.6	23.8	31.5
Kearney.....	313, 121	217, 326	70, 071	29, 738	10, 511	37, 700	25, 224	63.6	23.2	32.2
Keith.....	461, 151	89, 733	238, 241	35, 868	64, 261	252, 120	24, 169	19.9	74.7	375.8
Keyapaha.....	369, 120	112, 857	238, 241	35, 868	64, 261	252, 120	24, 169	28.3	59.7	211.2
Kimball.....	264, 525	25, 308	124, 559	30, 403	2, 060	112, 676	67, 895	9.6	47.1	492.2
Knox.....	612, 710	337, 493	207, 322	67, 752	26, 894	112, 676	67, 895	55.1	33.8	61.4
Lancaster.....	509, 870	353, 978	102, 006	58, 717	17, 567	53, 876	69.4	20.0	98.8	
Lincoln.....	1, 216, 275	318, 197	818, 168	195, 070	21, 320	601, 778	79, 870	26.2	67.3	257.1
Logan.....	253, 001	57, 861	123, 640	20, 065	3, 140	100, 435	71, 500	22.9	48.9	213.7
Loup.....	257, 963	51, 043	177, 817	10, 451	1, 187	166, 179	29, 103	10.8	68.0	348.4
McPherson.....	387, 211	69, 174	266, 943	85, 319	1, 375	180, 240	51, 094	17.9	68.9	385.9
Madison.....	350, 512	238, 288	90, 013	50, 290	11, 148	98, 577	22, 211	37.8	37.8	
Merrick.....	278, 353	162, 917	97, 178	66, 314	7, 248	23, 616	18, 228	38.5	34.9	59.7
Morrill.....	499, 869	182, 730	202, 443	63, 857	1, 247	137, 339	214, 696	16.6	40.5	244.7
Nance.....	250, 282	164, 819	60, 886	19, 206	14, 492	27, 188	24, 577	65.8	24.3	36.9
Nemaha.....	236, 500	161, 086	53, 591	30, 478	17, 852	5, 261	22, 173	68.0	22.6	33.3
Nuckolls.....	337, 691	224, 113	82, 705	20, 733	11, 985	49, 987	30, 873	60.5	24.5	36.9
Otoe.....	377, 013	264, 174	78, 221	52, 362	16, 815	9, 044	34, 618	70.1	20.7	29.6
Pawnee.....	257, 944	156, 359	75, 653	30, 232	19, 763	25, 658	25, 932	60.6	29.3	48.4
Perkins.....	279, 777	69, 007	187, 270	110, 965	8, 735	67, 570	29, 500	24.7	66.9	271.4
Phelps.....	328, 014	224, 959	71, 978	42, 664	2, 874	26, 440	31, 077	68.6	21.9	32.0
Pierce.....	332, 176	215, 576	85, 013	39, 937	5, 101	39, 975	31, 587	64.9	25.6	30.4
Platte.....	411, 238	291, 738	90, 942	65, 633	10, 892	14, 417	28, 558	70.9	22.1	31.2
Polk.....	268, 530	206, 221	56, 128	20, 909	3, 546	22, 673	6, 181	76.8	20.9	27.2
Redwillow.....	418, 603	208, 732	151, 826	40, 907	2, 971	107, 948	60, 045	49.4	36.3	73.5
Richardson.....	331, 025	191, 889	91, 044	51, 212	24, 247	135, 585	48, 092	58.0	27.5	47.4
Rock.....	488, 121	137, 194	180, 346	20, 034	5, 280	135, 032	170, 581	28.1	36.9	131.4
Saline.....	357, 503	261, 275	71, 143	30, 415	16, 565	24, 163	25, 085	73.1	19.9	27.2
Sarpy.....	132, 947	92, 255	25, 974	11, 434	11, 477	3, 063	14, 718	69.4	19.5	28.2
Saunders.....	464, 526	98, 173	58, 653	34, 172	14, 589	19, 931	29, 881	73.5	20.1	27.3
Scotts Bluff.....	291, 026	85, 375	123, 090	22, 186	9, 081	91, 823	82, 561	29.3	42.3	144.2
Seward.....	354, 434	260, 436	71, 038	37, 792	17, 659	15, 587	22, 960	73.5	20.0	27.3
Sheridan.....	1, 135, 477	187, 068	811, 383	233, 851	78, 784	498, 748	137, 026	16.5	71.5	433.7
Sherman.....	331, 179	176, 955	127, 412	23, 508	16, 630	82, 274	26, 812	53.4	38.5	72.0
Sioux.....	960, 557	79, 121	806, 085	231, 559	56, 354	518, 172	75, 651	8.2	83.9	1, 018.8
Stanton.....	262, 543	162, 945	76, 334	35, 361	6, 907	34, 066	23, 214	62.1	29.1	46.8
Thayer.....	354, 306	248, 737	88, 636	36, 087	19, 339	33, 210	16, 933	23.0	35.6	
Thomas.....	206, 992	28, 683	123, 951	22, 175	13, 493	88, 283	54, 358	13.9	58.9	32.1
Thurston.....	186, 001	134, 448	34, 197	15, 590	5, 081	13, 796	17, 356	72.3	18.4	25.4
Valley.....	342, 025	184, 447	132, 327	26, 245	15, 132	90, 960	23, 251	53.9	38.7	71.8
Washington.....	239, 733	160, 672	55, 291	33, 551	15, 299	6, 441	23, 770	67.0	23.1	34.4
Wayne.....	274, 857	205, 753	57, 556	48, 226	9, 956	8, 374	11, 948	74.9	20.9	28.0
Webster.....	359, 528	220, 499	109, 197	36, 153	10, 995	62, 049	30, 132	61.3	30.4	49.5
Wheeler.....	316, 776	66, 366	101, 573	25, 758	25, 071	145, 837	50, 740	32.1	53.0	
York.....	360, 042	281, 895	63, 745	37, 509	10, 329	15, 907	14, 402	78.3	17.7	22.6
Total.....	38, 022, 021	17, 318, 011	16, 398, 680	4, 552, 087	1, 282, 722	10, 563, 871	4, 405, 330	44.8	42.5	94.7

^a See table of counties reporting an excessive acreage in pasture, on page 13.

TABLE II.—*Pasture land on farms in the United States, by counties (1910 census)*—Continued.

County.	Total land in farms.	Land in crops.	Pasture land.				All other farm land.	Percentage of total farm land de- voted to—		Acres in pasture per 100 acres in crops.
			Improved.		Woodland.	Other.		Crops.	Pasture.	
			Total.	Improved.						
NEVADA.										
Churchill.....	113,183	20,018	28,926	3,624	2,589	22,793	64,289	17.7	25.6	144.5
Clark.....	20,721	3,590	5,303	1,209	1,484	2,610	11,828	17.3	23.6	147.7
Douglas.....	84,194	19,324	51,752	8,639	2,888	40,225	13,118	23.0	61.5	267.9
Elko.....	926,385	115,942	1,256,441	740,227	74,433	441,781	(a)	12.5	135.6	1,084.1
Esmeralda.....	33,212	6,830	20,536	3,021	8,081	9,434	5,846	20.6	61.8	300.7
Eureka.....	73,625	12,465	43,936	16,067	750	27,119	17,223	16.9	59.7	332.3
Humboldt.....	666,880	92,507	450,262	72,088	22,593	355,881	123,911	13.9	67.5	486.7
Lander.....	249,736	22,060	679,373	12,708	3,983	662,682	148,303	8.8	31.8	339.6
Lincoln.....	29,958	5,241	17,237	6,796	18	10,423	7,480	17.5	57.5	328.9
Lyon.....	105,562	28,574	40,474	10,519	2,888	27,067	36,514	27.1	38.3	141.7
Nye.....	94,614	12,922	57,438	31,200	1,297	24,941	24,254	13.7	60.7	444.5
Ormsby.....	10,472	1,787	5,022	631	1,440	2,951	3,663	17.1	48.0	281.0
Storey.....	1,498	541	741	452	49	210	216	36.1	49.5	137.0
Washoe.....	195,286	38,168	190,328	21,825	137,912	30,590	(a)	19.5	97.5	499.4
White Pine.....	169,631	14,249	16,902	5,876	290	10,736	78,480	13.0	15.4	118.6
Total.....	2,714,757	394,159	2,264,671	939,973	255,555	1,069,143	55,927	14.5	83.4	574.5
NEW HAMPSHIRE.										
Belknap.....	203,567	39,864	84,461	3,390	52,712	28,359	79,242	19.6	41.5	211.9
Carroll.....	240,162	40,242	76,579	3,917	52,967	17,725	163,341	14.4	27.3	190.3
Cheshire.....	323,737	51,439	103,839	5,621	65,199	33,019	168,359	15.9	32.1	201.9
Coos.....	273,670	58,063	102,048	9,355	47,924	44,769	113,529	21.2	37.3	175.7
Grafton.....	560,820	110,794	205,916	16,583	134,723	54,610	244,110	19.8	36.7	188.9
Hillsboro.....	386,447	74,138	149,834	9,692	93,834	46,295	162,475	19.2	38.8	202.1
Merrimack.....	443,708	85,251	181,092	10,395	137,242	33,455	177,365	19.2	40.8	212.4
Rockingham.....	325,742	82,462	125,269	9,873	85,467	29,929	118,011	25.3	38.5	151.9
Stratford.....	172,720	40,246	61,728	5,338	45,262	11,128	70,746	23.3	33.7	153.4
Sullivan.....	278,885	52,833	121,006	3,785	66,914	50,307	105,046	18.9	43.4	229.0
Total.....	3,249,458	635,362	1,211,772	79,949	782,227	349,596	1,402,324	19.6	37.3	190.7

NEW JERSEY.

Atlantic.....	72,957	24,614	1,320	631	156	533	47,023	33.7	1.8	5.4
Bergen.....	52,726	19,201	8,453	2,981	3,129	2,343	25,072	36.4	16.0	44.0
Burlington.....	287,816	125,083	41,991	26,621	4,004	11,366	119,742	43.8	14.6	33.3
Camden.....	64,933	35,161	6,731	3,946	916	1,869	23,041	54.2	10.4	19.1
Cape May.....	42,106	12,485	4,762	1,246	1,283	2,293	24,859	29.7	11.3	38.1
Cumberland.....	158,553	72,870	11,722	5,922	2,660	3,140	74,461	45.6	17.4	16.2
Essex.....	222,783	100,656	4,129	3,432	2,632	1,065	7,998	46.8	18.1	38.7
Gloucester.....	139,687	74,401	15,516	8,464	2,424	4,628	50,070	53.0	11.1	20.9
Hudson.....	1,395	1,006	70	6	40	24	519	63.1	4.4	7.0
Hunterdon.....	244,085	137,771	40,065	19,968	11,829	8,298	66,219	56.4	16.4	29.1
Mercer.....	123,570	72,446	16,129	7,486	3,571	5,072	34,995	58.6	13.0	22.3
Middlesex.....	107,874	60,774	8,704	4,721	2,064	1,919	38,396	56.3	8.1	14.3
Monmouth.....	206,856	102,392	23,371	13,796	4,669	4,906	81,063	49.5	11.3	24.8
Morris.....	168,019	60,033	34,573	9,034	15,557	9,982	73,413	35.7	20.6	37.6
Ocean.....	53,648	15,903	6,403	3,824	1,848	731	31,342	29.6	11.9	40.3
Passaic.....	46,304	16,608	11,347	2,200	6,660	2,479	18,349	35.9	24.5	68.3
Salem.....	168,696	86,510	29,492	19,155	1,858	8,479	52,694	51.3	17.5	34.1
Somerset.....	165,966	92,688	29,009	16,666	5,560	6,783	41,269	55.8	17.5	31.3
Sussex.....	238,311	77,678	95,968	54,373	21,138	20,457	69,665	30.5	40.3	132.0
Union.....	23,405	11,919	4,538	2,034	1,629	875	6,848	56.9	38.1	19.4
Warren.....	153,967	83,302	38,565	22,264	8,078	8,523	59,800	46.4	21.1	45.6
Total.....	2,573,857	1,190,761	433,188	225,770	101,705	105,713	949,968	46.3	16.8	36.4

NEW MEXICO.

Bernalillo.....	112,774	12,226	57,040	6,145	5,971	44,924	43,508	10.8	50.6	466.5
Chaves.....	1,049,606	58,992	689,718	18,418	6,081	665,219	300,896	5.6	65.7	1,169.2
Colfax.....	1,375,846	31,123	981,179	122,031	354,973	504,175	363,544	2.3	71.3	3,152.6
Curry.....	502,111	68,720	153,644	35,156	13,402	105,086	279,747	13.7	30.6	223.6
Doña Ana.....	24,412	35,168	1,210	1,210	31,713	2,245	24,955	28.9	41.6	144.1
Eddy.....	352,758	40,638	117,296	8,153	1,006	108,137	194,824	11.5	33.2	288.6
Grant.....	176,449	11,019	134,756	20,698	23,004	82,054	30,674	6.2	76.4	1,222.9
Guadalupe.....	507,650	18,329	399,309	124,196	21,927	253,186	90,012	3.6	78.7	2,175.6
Lincoln.....	157,715	8,441	112,134	14,258	43,179	54,697	37,140	5.4	71.1	1,398.4
Luna.....	96,402	4,730	36,967	6,569	3,030	27,368	54,705	4.9	38.3	781.5
McKinley.....	56,685	3,049	3,742	6,517	520	2,705	49,894	5.4	6.6	122.7
Mora.....	601,515	33,198	333,088	32,072	116,662	210,394	206,229	5.5	59.7	1,081.7
Otero.....	147,734	9,714	82,887	4,181	64,721	13,985	35,133	6.6	56.1	853.3
Quay.....	730,937	70,291	492,660	151,086	3,082	338,492	167,986	9.6	67.4	700.9
Rio Arriba.....	223,870	18,509	131,765	5,911	57,508	68,346	73,596	8.3	58.8	711.9
Roosevelt.....	740,825	86,454	451,179	146,064	81,842	223,273	203,192	11.7	60.9	521.9
Sandoval.....	349,299	12,639	273,813	38,702	108,028	127,083	62,847	3.6	78.4	2,166.4

^a See table of counties reporting an excessive acreage in pasture, on p. 13.

^b Estimated.

TABLE II.—*Pasture land on farms in the United States, by counties (1910 census)*—Continued.

County.	Total land in farms.	Land in crops.	Pasture land.				All other farm land.	Percentage of total farm land devoted to—		Acres in pasture per 100 acres in crops.
			Total.	Improved.	Woodland.	Other.		Crops.	Pasture.	
NEW MEXICO—Continued.										
San Juan.....	100,289	16,829	23,164	1,824	5,034	16,306	60,296	16.8	29.9	178.4
San Miguel.....	1,044,726	21,046	903,773	30,024	133,047	740,702	119,907	2.0	86.5	4,294.3
Santa Fe.....	236,279	11,921	176,604	42,569	56,228	77,807	47,754	5.0	74.7	1,481.5
Sierra.....	507,636	2,309	403,274	150,211	11,356	301,707	42,053	1.5	91.3	20,063.8
Socorro.....	626,670	10,369	404,735	68,009	106,015	230,711	211,536	1.7	64.6	3,892.0
Taos.....	95,540	14,508	40,313	9,170	16,369	14,719	40,718	15.2	42.2	277.9
Torrance.....	369,774	25,348	100,988	29,153	24,511	47,324	243,438	6.9	27.3	398.4
Union.....	814,011	33,241	141,629	12,062	169	129,398	639,141	4.1	17.4	426.1
Valencia.....	208,385	12,697	173,192	11,738	25,086	136,368	22,496	6.1	83.1	1,364.0
Total.....	11,270,021	660,782	6,940,017	1,090,127	1,323,464	4,526,426	3,669,222	5.9	61.6	1,050.3
NEW YORK.										
Albany.....	289,829	149,973	52,749	27,059	15,364	10,326	87,107	51.8	18.2	35.2
Allegany.....	585,615	224,377	229,478	75,334	84,245	69,899	131,700	38.3	39.2	102.3
Broome.....	411,475	145,765	159,153	96,019	34,222	28,912	106,557	35.4	38.7	109.2
Cattaraugus.....	669,940	207,325	325,453	141,058	105,768	78,627	136,982	31.0	48.6	156.8
Cayuga.....	111,170	228,019	89,446	42,411	28,980	18,055	98,705	55.5	21.8	39.2
Chautauqua.....	613,000	224,548	277,786	113,696	99,780	64,310	110,666	36.6	45.3	123.7
Chemung.....	226,772	91,120	55,387	35,220	16,219	80,265	40,265	40.2	24.4	60.8
Chemung.....	539,084	180,756	258,830	139,265	55,350	64,215	99,498	33.5	48.0	143.2
Clinton.....	450,324	146,117	192,829	21,939	98,529	76,825	111,914	32.4	42.7	131.6
Columbia.....	374,415	178,077	92,394	55,094	24,179	13,121	103,944	47.6	24.7	51.9
Cortland.....	290,707	112,097	134,299	62,793	40,252	31,254	53,311	37.4	44.8	119.8
Delaware.....	768,131	203,168	318,612	176,157	79,155	63,300	246,351	26.5	41.5	156.8
Dutchess.....	464,202	179,137	149,875	91,081	30,775	28,019	135,196	38.6	32.3	83.7
Erie.....	571,386	288,806	165,982	57,781	62,703	45,498	117,098	50.5	29.0	57.6
Essex.....	359,008	77,948	140,453	19,854	99,480	21,119	140,607	21.7	39.1	180.2
Franklin.....	429,437	130,139	175,003	31,138	58,614	84,251	121,285	30.3	40.8	134.5
Fulton.....	205,845	66,919	13,751	13,751	31,124	22,044	72,556	32.5	32.5	100.8
Genesee.....	289,187	157,174	49,012	16,084	18,121	14,807	83,001	34.3	16.9	31.2

Greene.....	115,048	108,014	29,611	33,137	45,266	86,062	37.2	34.9	93.9
Hamilton.....	10,504	21,310	3,251	13,147	4,912	26,673	18.6	37.7	203.0
Herkimer.....	132,058	173,047	86,309	48,861	37,877	66,864	35.5	46.5	131.0
Jefferson.....	336,793	321,866	117,005	93,333	111,528	74,202	46.0	43.9	95.6
Kings.....	1,259	33	3	30	.....	151	87.2	2.3	2.6
Lewis.....	133,443	219,963	70,073	67,331	82,554	121,627	28.1	46.3	164.9
Livingston.....	190,926	117,735	55,051	45,541	17,143	80,875	49.0	30.2	61.7
Madison.....	162,574	171,921	82,668	53,701	34,652	47,539	42.7	44.8	105.0
Monroe.....	263,137	53,703	30,136	13,083	10,481	68,456	68.3	13.9	20.4
Montgomery.....	134,850	57,965	33,894	15,087	9,012	41,198	57.6	22.8	43.0
Nassau.....	33,628	4,239	2,789	1,011	.....	17,883	60.3	7.6	12.7
New York.....	1,965	328	209	26	3	17,990	32.9	16.7	50.7
Niagara.....	305,800	224,907	29,298	14,059	7,084	30,452	73.5	16.5	22.4
Oneida.....	690,431	246,040	133,603	74,373	86,980	149,335	35.6	42.7	119.9
Onondaga.....	223,356	118,644	66,941	29,920	22,783	95,658	51.1	27.1	53.1
Ontario.....	222,882	69,664	32,283	23,449	13,932	95,423	57.4	18.0	31.3
Orange.....	149,820	133,431	60,260	36,012	37,159	100,894	39.0	34.7	89.1
Orleans.....	157,848	36,913	17,207	9,471	10,235	38,131	67.8	15.8	23.4
Oswego.....	167,809	223,355	83,554	89,676	50,125	100,831	34.1	45.4	133.1
Otsego.....	222,866	229,598	145,930	49,544	34,119	140,072	37.6	38.7	103.0
Putnam.....	30,736	44,725	13,789	15,025	15,911	34,242	28.0	40.8	145.5
Queens.....	11,874	410	293	66	51	2,304	81.4	2.8	3.5
Rensselaer.....	163,322	120,775	41,702	42,369	36,561	81,215	41.7	33.0	73.9
Richmond.....	3,035	224	212	11	1	2,061	57.0	4.2	7.4
Rockland.....	19,093	8,769	2,830	3,869	2,050	24,255	36.6	16.8	45.9
St. Lawrence.....	351,237	528,886	113,940	151,053	260,893	181,393	33.1	49.8	150.6
Saratoga.....	135,040	106,058	36,114	45,031	24,313	151,087	34.4	27.0	78.6
Schenectady.....	56,117	19,864	7,787	7,499	4,578	30,270	52.8	13.7	35.4
Schoharie.....	155,400	114,949	71,205	17,347	26,397	100,727	41.9	31.0	74.0
Schuyler.....	93,329	36,429	21,477	9,234	5,718	60,274	49.1	19.2	39.0
Seneca.....	171,793	29,220	14,407	11,513	3,300	44,092	61.6	15.3	24.8
Steuben.....	364,332	190,008	92,280	70,213	36,515	255,033	44.5	24.3	54.6
Suffolk.....	64,914	26,956	8,562	14,468	3,926	86,193	36.4	15.1	41.5
Sullivan.....	99,912	145,932	40,569	69,310	36,064	205,361	22.1	32.3	146.1
Tioga.....	111,660	81,885	51,286	18,879	12,720	104,978	37.4	27.4	73.4
Tompkins.....	273,022	63,944	36,130	15,034	12,720	73,987	48.8	23.4	48.0
Ulster.....	147,491	119,713	36,722	50,025	32,966	229,501	29.7	24.1	81.2
Warren.....	47,590	13,536	60,605	17,470	111,178	19.0	36.6	31.6	192.6
Washington.....	170,337	141,008	72,191	43,461	25,334	135,113	38.1	31.6	82.8
Wayne.....	214,830	37,391	14,836	13,590	18,227	72,576	60.0	19.7	32.8
Westchester.....	337,890	70,454	20,736	13,590	14,213	42,563	37.6	33.3	88.6
Windsor.....	145,837	54,795	53,166	38,562	36,169	80,816	47.1	34.3	77.7
Wyoming.....	164,731	127,897	16,673	13,091	5,118	51,820	57.5	17.1	29.7
Yates.....	117,512	34,882	.....	.....	.....	.....	.....	.....	.....
Total.....	8,949,592	7,501,610	3,098,982	2,417,633	1,985,025	5,579,135	40.6	34.1	83.8

TABLE II.—*Pasture land on farms in the United States, by counties (1910 census)*—Continued.

County.	Total land in farms.	Land in crops.	Pasture land.				All other farm land.	Percentage of total farm land devoted to—		Acres in pasture per 100 acres in crops.
			Total.	Improved.	Woodland.	Other.		Crops.	Pasture.	
NORTH CAROLINA.										
Alamance.....	252,578	66,537	32,742	7,525	19,771	5,446	153,299	26.3	13.0	49.2
Alexander.....	159,944	44,717	19,931	6,042	8,930	4,959	95,296	28.0	12.5	41.6
Alleghany.....	139,966	30,563	57,843	48,570	6,646	6,646	61,560	20.4	38.6	189.3
Anson.....	289,900	96,742	22,670	3,217	17,615	1,838	170,578	33.4	7.8	23.4
Ashe.....	266,825	54,131	96,220	79,195	14,827	2,198	116,474	20.3	36.1	77.8
Beaufort.....	219,100	58,075	6,203	613	5,084	2,668	184,822	23.3	2.5	10.7
Bertie.....	282,471	76,977	6,023	464	2,891	1,380	199,471	27.2	2.1	7.8
Bladen.....	287,773	46,432	21,315	2,502	17,433	1,380	220,006	16.1	7.4	45.9
Brunswick.....	268,102	20,152	41,461	876	1,872	38,713	206,489	7.5	15.5	205.8
Buncombe.....	419,782	70,114	90,609	29,099	45,241	16,269	259,059	16.7	21.6	129.2
Burke.....	222,882	52,024	17,998	5,208	11,189	1,601	152,860	23.3	8.1	34.6
Cabarrus.....	207,426	78,383	23,622	5,021	15,672	2,929	105,421	37.8	11.4	30.1
Caldwell.....	218,371	45,705	26,026	8,273	14,696	3,057	146,640	20.9	11.9	56.9
Camden.....	60,013	26,902	1,632	937	273	422	61,419	44.9	2.7	6.1
Carters.....	77,181	13,360	2,152	48	896	1,208	61,669	17.3	2.8	16.1
Caswell.....	263,870	45,819	22,725	6,590	14,083	2,043	195,326	17.4	8.6	49.6
Catawba.....	241,037	87,188	24,550	6,282	13,264	5,004	129,290	36.2	10.2	28.2
Chatham.....	379,632	87,036	41,334	4,775	28,504	8,055	251,262	22.9	10.9	47.5
Cherokee.....	201,025	30,502	14,327	1,989	11,471	867	136,786	13.1	7.1	47.0
Chowan.....	74,363	24,451	4,632	83	524	25	49,477	32.8	8	2.6
Clay.....	82,005	16,527	12,213	2,779	8,457	977	53,865	20.0	14.8	73.9
Cleveland.....	262,888	107,671	33,933	3,881	22,993	7,059	121,284	41.0	12.9	31.5
Columbus.....	333,416	60,747	6,273	381	4,261	1,631	266,396	18.2	1.9	10.3
Craven.....	202,238	37,900	3,399	316	2,938	145	190,939	18.7	1.7	9.0
Cumberland.....	407,586	91,421	6,093	747	5,118	228	310,072	22.4	1.5	6.7
Currituck.....	87,353	25,278	2,234	622	1,490	122	59,841	28.9	2.6	8.8
Dare.....	7,231	1,406	162	49	113	.....	5,663	19.4	2.2	11.5
Davidson.....	331,259	99,440	38,896	8,488	23,102	7,306	192,923	30.0	11.7	39.1
Davie.....	155,579	50,561	16,467	3,026	11,009	2,432	88,551	32.5	10.6	32.6
Duplin.....	392,635	73,586	9,981	4,555	4,433	1,193	309,068	18.7	2.5	13.6
Durham.....	137,377	28,973	20,043	2,027	17,103	1,933	88,341	21.1	14.6	69.2
Edgecombe.....	283,069	113,663	26,279	1,970	22,329	1,980	138,127	40.1	9.3	23.1
Forsyth.....	224,805	18,724	24,198	4,351	16,919	2,928	128,883	31.0	10.9	35.2
Franklin.....	258,120	78,463	20,506	2,231	11,421	3,854	159,151	30.4	7.9	26.1
Gaston.....	199,951	78,249	20,001	4,165	13,537	2,299	101,701	39.1	10.0	25.6

TABLE II.—*Pasture land on farms in the United States, by counties (1910 census)*—Continued.

County.	Total land in farms.	Land in crops.	Pasture land.				All other farm land.	Percentage of total farm land de- voted to—		Acres in pasture per 100 acres in crops.
			Total.	Improved.	Woodland.	Other.		Crops.	Pasture.	
NORTH CAROLINA—Continued.										
Tyrrell.....	56,375	13,018	3,359	3,334	11	14	39,998	23.1	6.0	25.8
Union.....	359,956	111,862	32,959	3,783	25,389	3,787	215,135	31.1	9.2	29.5
Vance.....	156,736	37,593	10,716	1,248	7,871	1,597	108,457	24.0	6.8	28.5
Wake.....	481,022	135,256	40,960	3,572	31,250	6,138	304,776	28.1	8.5	30.3
Warren.....	212,391	58,544	19,457	2,792	11,052	5,643	134,390	27.6	9.2	33.2
Washington.....	84,344	26,190	8,848	2,207	4,300	2,341	49,306	31.1	10.5	33.8
Watauga.....	232,260	34,367	55,654	36,955	13,672	4,997	142,239	14.8	24.0	161.9
Wayne.....	322,142	124,506	16,228	1,612	13,109	1,507	181,408	38.6	5.0	13.0
Wilkes.....	411,230	80,964	44,922	11,142	28,427	5,353	285,344	19.7	10.9	55.5
Wilson.....	197,203	89,250	10,821	394	9,351	1,076	97,132	45.3	5.5	12.1
Yadkin.....	208,201	58,962	21,398	4,331	14,343	2,724	127,841	28.3	10.3	36.3
Yancey.....	164,940	31,320	25,574	13,927	9,401	2,246	108,046	19.0	15.5	81.7
Total.....	22,439,129	5,924,906	2,056,413	567,532	1,194,679	294,202	14,457,750	26.4	9.2	34.8

Grand Forks.....	823,900	606,281	83,945	40,526	18,685	24,734	133,674	73.6	10.2	13.8
Griggs.....	406,144	273,444	47,518	8,600	4,426	34,402	55,182	67.3	11.7	17.4
Hettinger.....	357,892	142,470	30,967	1,283	8,956	20,728	1,844,455	39.8	8.7	21.7
Kidder.....	341,153	152,805	66,868	21,782	8,365	44,721	121,390	44.8	19.6	43.0
Lamoure.....	624,345	429,773	90,201	49,939	8,725	31,517	104,371	68.8	14.4	21.8
Logan.....	403,872	185,662	110,119	25,949	6,335	77,865	108,031	46.0	22.6	59.3
McHenry.....	876,933	545,735	110,122	60,492	7,149	42,481	221,076	62.2	12.3	20.2
McIntosh.....	407,584	205,795	47,601	11,566	9,675	35,428	214,188	44.0	10.2	23.1
McKenzie.....	277,857	98,374	30,388	8,210	6,807	12,303	149,085	35.4	10.9	30.9
McLean.....	837,250	428,071	118,894	44,205	4,121	70,568	290,285	51.1	14.2	27.8
Mercer.....	286,775	120,742	88,136	23,153	1,378	63,005	77,897	42.0	30.7	73.0
Morton.....	326,450	189,141	553,911	222,239	6,721	321,951	583,398	14.3	41.8	292.9
Mountain.....	444,280	344,280	94,628	32,814	4,987	56,227	(a)	87.6	18.7	21.3
Neison.....	388,799	83,105	31,694	3,920	3,920	47,491	122,220	64.2	14.5	22.5
Oliver.....	282,791	102,458	75,601	9,242	284	66,075	104,732	36.2	26.7	73.8
Pembina.....	600,803	390,809	79,710	23,851	42,374	13,485	130,284	65.0	13.3	20.4
Pierce.....	353,202	64,788	64,788	30,102	6,261	24,045	136,890	68.7	11.7	18.3
Ramsey.....	438,656	438,656	64,685	33,573	6,261	24,045	104,074	68.7	9.7	14.7
Ransom.....	308,472	308,472	72,722	23,328	10,293	34,101	75,059	67.1	13.9	23.6
Renville.....	314,437	314,437	48,319	24,456	1,958	21,905	135,525	63.1	9.7	15.4
Richland.....	733,973	336,882	62,685	50,267	14,278	28,140	134,406	71.2	12.3	17.3
Rolette.....	227,141	69,256	30,183	19,520	19,520	19,583	145,050	51.4	15.7	30.5
Sargent.....	484,909	313,491	94,029	35,730	1,314	56,985	77,389	64.6	19.4	30.0
Sheridan.....	229,055	16,476	60,083	16,476	135	43,472	129,280	54.7	14.4	26.2
Stark.....	418,418	177,980	219,204	91,192	960	127,052	143,327	32.9	40.6	123.2
Steele.....	540,511	320,540	34,403	7,808	4,490	22,045	77,971	74.0	8.0	10.7
Stutsman.....	894,474	525,431	144,605	42,755	6,814	95,036	224,438	58.7	16.2	27.5
Towner.....	555,207	363,471	36,875	24,408	139	12,328	154,861	65.4	6.6	10.1
Trail.....	598,729	376,584	40,390	22,768	11,141	6,481	111,755	71.2	7.6	10.7
Walsh.....	758,974	510,974	78,874	25,577	33,902	19,395	169,136	67.2	10.4	15.4
Ward.....	495,666	127,024	49,277	6,145	71,602	293,591	54.2	13.9	23.6	
Wells.....	681,351	437,615	81,104	35,158	485	43,471	102,602	64.2	11.9	18.5
Williams.....	780,983	251,983	64,688	10,267	495	53,956	440,310	35.8	8.2	22.9
Total.....	28,426,650	15,890,793	4,386,296	1,635,384	330,998	2,399,904	8,149,571	55.9	15.4	27.6

OHIO.

Adams.....	327,409	104,630	128,104	82,436	23,798	21,870	49,675	32.0	39.1	122.5
Allen.....	240,472	146,144	66,558	31,281	30,031	5,246	27,770	60.8	27.7	45.5
Ashland.....	138,525	135,401	69,040	31,798	27,936	9,306	54,071	52.4	26.7	51.0
Ashtabula.....	399,187	101,801	168,342	57,606	66,701	43,975	69,044	40.5	42.2	104.0
Athens.....	286,923	68,348	150,985	92,878	40,010	24,097	61,590	23.8	54.7	230.0
Auglaize.....	297,509	147,734	56,433	25,966	24,208	6,199	33,342	62.2	23.8	38.2
Belmont.....	318,728	114,139	148,131	107,089	28,570	12,472	56,458	35.8	46.5	129.8
Brown.....	303,447	124,281	122,239	100,067	15,107	7,065	56,927	41.0	40.3	98.4
Butler.....	278,863	166,580	69,882	27,313	24,497	17,572	42,901	59.7	24.9	41.6

a See table of counties reporting an excessive acreage in pasture, on page 13.

TABLE II.—*Pasture land on farms in the United States, by counties (1910 census)*—Continued.

County.	Total land in farms.	Land in crops.	Pasture land.				All other farm land.	Percentage of total farm land devoted to—		Acres in pasture per 100 acres in crops.
			Total.	Improved.	Woodland.	Other.		Crops.	Pasture.	
OHIO—Continued.										
Carroll.....	239,888	95,515	104,819	78,869	15,027	10,323	39,554	33.8	43.7	109.1
Champaign.....	226,240	154,620	68,842	35,403	23,234	10,145	32,778	60.4	21.9	44.5
Clark.....	241,631	145,632	68,054	35,559	18,323	13,372	37,925	60.3	28.2	46.7
Clermont.....	274,210	127,520	89,356	55,329	19,799	14,298	57,334	46.5	32.6	70.1
Clinton.....	260,404	157,752	77,736	40,942	19,432	3,362	24,916	60.6	20.9	49.3
Columbiana.....	312,190	140,913	90,616	40,328	25,771	24,317	80,661	45.1	29.0	64.3
Coshocton.....	343,597	124,658	143,000	117,556	14,129	11,313	76,539	36.1	41.6	115.2
Crawford.....	245,412	147,501	62,189	29,761	27,650	5,378	35,722	60.1	25.3	42.2
Cuyahoga.....	217,730	107,027	67,739	16,111	24,422	27,206	42,964	49.2	31.1	63.3
Darke.....	372,180	262,655	73,940	35,323	30,443	8,174	35,585	70.6	19.9	28.1
Defiance.....	249,682	143,920	70,465	21,178	39,244	10,023	35,297	57.6	28.2	49.0
Delaware.....	276,582	143,340	106,961	62,311	38,104	6,546	26,281	51.8	38.7	74.6
Erie.....	114,319	83,368	32,989	12,266	10,104	10,619	20,022	59.1	22.9	38.7
Fairfield.....	301,067	163,911	86,886	64,553	14,732	7,601	50,270	54.4	28.9	53.0
Fayette.....	249,140	150,911	83,921	68,536	12,947	3,138	14,368	60.6	33.7	55.6
Franklin.....	306,261	195,378	85,566	57,899	20,548	7,119	25,317	63.8	27.9	43.8
Fulton.....	246,256	141,811	62,634	26,130	27,166	9,338	41,811	57.6	25.4	44.2
Galla.....	273,942	75,392	124,455	93,580	15,832	14,043	74,095	27.5	45.1	165.1
Geauga.....	239,505	76,916	97,374	34,972	32,857	31,439	65,215	32.1	40.7	126.6
Greene.....	258,698	149,655	70,655	34,972	25,207	10,835	38,388	57.8	27.3	47.2
Guernsey.....	311,886	99,101	158,502	122,460	25,207	10,835	54,283	31.8	50.8	159.9
Hamilton.....	197,775	104,719	55,249	21,629	17,518	16,102	37,807	52.9	27.0	52.8
Hancock.....	319,419	193,345	76,588	38,362	27,826	10,400	49,486	60.5	24.9	39.6
Hardin.....	279,905	163,550	71,413	37,984	30,270	3,209	44,942	58.4	25.5	43.7
Harrison.....	245,429	77,789	133,575	16,037	14,313	18,120	31,870	31.7	54.4	171.7
Henry.....	254,550	174,921	47,759	16,037	27,839	3,838	50,066	43.9	18.8	27.3
HIGHLAND.....	343,029	151,555	143,399	112,216	23,897	7,346	90,066	25.5	40.6	153.2
Hocking.....	225,928	57,560	91,688	67,050	11,746	12,862	76,710	49.6	46.6	54.5
Holmes.....	258,403	128,200	69,825	38,511	19,813	11,501	60,378	28.4	27.0	50.9
Huron.....	290,923	162,576	82,690	33,103	28,404	21,133	45,657	55.9	28.4	229.2
Jackson.....	237,014	58,827	134,821	92,607	26,982	15,232	43,366	24.8	56.9	146.1
Jefferson.....	229,405	74,898	109,456	53,099	41,676	14,681	45,051	32.6	47.7	89.8
Knox.....	324,716	140,038	126,212	92,222	27,007	11,333	57,866	44.3	27.1	61.3
Lake.....	130,748	57,824	35,432	10,879	15,334	9,019	37,492	43.2	33.0	108.1
Lawrence.....	205,345	62,639	67,696	38,418	19,088	10,193	75,007	30.5		

Licking.....	414, 806	186, 585	171, 601	132, 344	30, 673	8, 581	56, 620	45.0	41.4	92.0
Logan.....	278, 978	135, 721	89, 492	40, 993	37, 828	10, 671	33, 705	55.8	32.1	57.5
Lorain.....	426, 729	143, 059	89, 316	42, 373	29, 736	17, 277	53, 354	50.1	31.3	62.4
Lucas.....	105, 457	104, 753	83, 490	11, 217	15, 413	6, 770	27, 264	63.3	20.2	31.9
Madison.....	286, 586	178, 730	88, 788	63, 636	21, 028	4, 124	19, 068	62.4	31.0	49.7
Mahoning.....	234, 999	99, 938	92, 324	23, 407	37, 420	31, 497	42, 737	42.5	30.3	42.4
Marion.....	242, 376	145, 085	68, 180	46, 984	17, 461	3, 735	29, 111	59.9	28.1	47.0
Medina.....	213, 968	129, 876	85, 346	21, 203	33, 179	30, 964	39, 746	50.9	33.5	63.7
Meigs.....	202, 846	70, 663	122, 805	89, 110	19, 316	14, 379	60, 378	27.8	48.4	173.8
Meer.....	277, 605	174, 219	66, 776	29, 370	35, 175	1, 281	36, 610	62.8	24.1	38.3
Miami.....	241, 557	181, 845	141, 787	19, 770	11, 734	7, 283	23, 824	73.8	16.9	23.0
Monroe.....	271, 577	84, 608	113, 399	80, 500	18, 705	14, 131	73, 573	31.2	41.8	134.0
Montgomery.....	278, 402	180, 374	55, 417	20, 568	22, 818	9, 561	32, 411	67.3	20.6	30.7
Morgan.....	294, 407	69, 380	142, 802	102, 536	21, 353	18, 893	42, 225	27.3	56.1	205.8
Morrow.....	239, 236	116, 368	96, 094	49, 706	33, 054	11, 334	36, 744	46.7	38.6	82.6
Muskingum.....	346, 442	130, 072	215, 305	168, 179	21, 969	25, 157	51, 065	32.8	54.3	163.5
Noble.....	212, 325	72, 375	144, 820	122, 200	14, 489	7, 570	25, 130	29.9	59.8	200.1
Ottawa.....	146, 887	100, 677	30, 677	21, 503	13, 923	6, 315	15, 533	68.5	20.9	30.5
Paulding.....	255, 609	178, 903	51, 244	63, 094	24, 941	4, 800	25, 462	70.0	20.0	28.6
Perry.....	225, 685	76, 020	99, 654	63, 094	20, 927	15, 633	49, 411	33.9	44.2	130.1
Pickaway.....	310, 422	191, 274	85, 532	66, 309	34, 448	4, 677	33, 616	61.6	27.6	41.7
Pike.....	212, 226	70, 921	63, 130	34, 448	18, 470	10, 212	108, 175	29.3	50.1	89.0
Portage.....	295, 552	115, 111	108, 407	23, 264	39, 496	45, 617	72, 034	38.9	36.7	94.2
Pueblo.....	265, 819	164, 090	67, 303	28, 363	28, 342	10, 658	34, 366	61.7	25.3	41.0
Putnam.....	292, 592	191, 094	72, 017	28, 343	33, 003	10, 605	28, 791	65.5	25.0	38.1
Rickland.....	303, 085	157, 811	125, 539	29, 169	37, 125	12, 472	72, 735	52.1	23.9	46.0
Ross.....	404, 171	172, 189	125, 783	17, 934	23, 693	10, 849	106, 199	42.6	31.1	73.0
Sandusky.....	247, 142	160, 632	52, 476	26, 748	39, 101	12, 535	119, 392	28.4	28.4	99.9
Scioto.....	276, 273	78, 497	78, 384	22, 916	37, 327	12, 293	52, 074	63.0	21.5	33.1
Seneca.....	336, 645	212, 035	56, 329	26, 822	24, 492	5, 015	31, 002	64.7	22.7	33.2
Shelby.....	247, 695	100, 364	71, 099	24, 620	23, 900	22, 579	73, 178	56.9	51.2	54.9
Stark.....	335, 382	191, 105	151, 355	56, 207	59, 150	35, 998	89, 133	34.3	41.4	120.7
Summit.....	227, 405	106, 527	58, 477	16, 857	24, 336	11, 414	80, 281	40.9	33.2	81.2
Tallmadge.....	365, 859	125, 371	125, 371	83, 722	28, 235	3, 340	15, 042	55.2	39.2	71.2
Tuscarawas.....	332, 536	135, 915	110, 340	74, 016	26, 014	2, 805	26, 716	26.9	20.7	26.9
Union.....	269, 064	148, 431	105, 591	22, 327	23, 087	14, 847	58, 419	21.3	51.7	242.0
Van Wert.....	250, 482	179, 960	51, 806	67, 800	26, 107	13, 062	31, 710	55.8	31.5	56.5
Vinton.....	216, 347	46, 174	111, 754	38, 710	26, 987	107, 739	31, 170	31.1	39.6	127.4
Warren.....	249, 783	139, 314	78, 739	89, 712	28, 793	18, 542	63, 080	59.0	22.3	37.8
Washington.....	368, 307	114, 006	145, 962	20, 709	35, 771	17, 457	42, 347	36.3	27.4	48.6
Wayne.....	336, 807	198, 705	75, 022	89, 712	32, 714	12, 943	49, 917	76.1	27.4	48.6
Williams.....	260, 255	146, 657	71, 251	26, 394	34, 401	9, 917	41, 090	31.1	27.4	24.6
Wood.....	360, 008	256, 007	62, 911	18, 533	16, 214	8, 713	34, 236	57.7	28.1	48.7
Wyandot.....	242, 102	139, 780	68, 086	43, 159	16, 214	8, 713	34, 236	57.7	28.1	48.7
Total.....	24, 105, 708	11, 843, 259	7, 973, 822	4, 536, 024	2, 284, 829	1, 152, 369	4, 288, 027	49.1	33.1	67.3

a Estimated.

Kingfisher.....	531,629	258,590	178,827	61,560	61,462	55,805	94,212	48.6	33.6	69.2
Kiowa.....	630,812	254,816	221,829	72,178	7,980	141,671	131,197	40.4	35.6	88.2
Latimer.....	48,174	17,276	7,849	1,963	3,943	1,943	23,049	35.9	16.3	43.4
Le Flore.....	180,588	90,275	17,027	4,178	11,330	1,519	73,286	50.0	9.4	18.9
Lincoln.....	506,927	252,424	252,048	18,812	202,408	30,798	92,455	42.3	42.2	90.9
Logan.....	449,481	200,481	168,746	42,515	92,574	33,657	71,254	46.6	37.5	80.6
Love.....	132,833	68,737	28,257	4,473	18,539	5,245	55,839	45.0	18.5	41.1
McClain.....	224,718	124,427	50,107	13,268	21,543	15,246	50,184	55.4	22.3	40.3
McCurran.....	137,823	30,494	18,485	2,256	12,586	3,643	79,844	28.7	13.4	46.8
McIntosh.....	234,887	138,826	57,666	10,922	35,785	10,959	38,365	59.1	24.6	41.5
Major.....	526,239	188,304	251,263	39,824	106,539	107,930	83,612	33.8	48.3	135.0
Marshall.....	152,999	82,543	38,061	5,830	16,661	15,561	32,385	54.0	24.9	46.1
Mays.....	227,446	94,421	47,306	18,238	12,457	16,011	85,719	51.1	20.8	50.1
Murray.....	180,309	57,524	70,102	7,880	15,967	46,625	52,683	31.9	38.9	121.9
Muskogee.....	320,891	147,427	159,818	57,775	36,368	36,675	13,646	45.9	49.8	108.4
Noble.....	431,629	198,904	148,022	30,514	27,934	80,574	84,703	46.1	34.3	74.4
Nowata.....	249,193	91,360	72,946	10,883	30,842	31,221	84,887	36.7	29.3	79.8
Okfuskee.....	232,828	88,094	50,048	4,836	37,135	8,077	94,686	37.8	21.5	56.8
Oklahoma.....	395,775	178,231	137,455	27,707	109,124	20,624	60,089	45.0	39.8	88.4
Oklumgee.....	334,869	96,974	173,689	38,814	74,549	60,326	64,206	29.0	51.9	179.1
Ossage.....	735,060	174,099	363,068	24,011	138,798	200,289	198,473	23.7	49.4	208.6
Ottawa.....	211,637	114,100	51,832	13,971	20,000	17,861	45,105	54.1	24.6	45.4
Payne.....	337,115	146,009	160,249	32,570	64,240	63,439	30,857	43.3	47.5	109.8
Pawnee.....	424,012	205,056	164,283	20,103	78,098	65,482	54,673	48.4	38.7	80.1
Pittsburg.....	219,472	86,110	74,290	14,666	43,091	16,333	80,072	34.5	29.8	86.3
Pontotoc.....	241,155	96,287	45,875	8,857	25,482	11,536	88,993	39.9	19.0	47.6
Pottawatomie.....	447,373	207,603	156,680	13,437	129,929	13,314	83,060	46.4	35.0	75.5
Pushmataha.....	80,611	21,965	12,587	738	11,479	370	46,032	27.3	15.6	57.2
Roger Mills.....	562,812	166,458	214,936	77,510	10,466	126,960	181,418	29.6	38.2	129.1
Rogers.....	312,561	104,921	121,867	38,014	28,155	55,698	57,773	33.6	39.0	88.5
Seminole.....	240,120	98,341	86,996	6,850	70,339	9,207	54,783	41.0	36.2	77.5
Sequoyah.....	190,899	99,133	19,369	4,439	13,015	1,895	72,397	51.9	10.1	19.5
Stephens.....	381,211	187,214	145,158	26,414	68,738	49,976	48,839	49.1	38.1	77.5
Texas.....	748,383	200,990	290,653	94,514	719	195,390	247,740	28.1	138.4	138.4
Tillman.....	429,833	231,985	110,308	34,752	3,405	72,151	87,560	54.0	25.7	47.4
Tulsa.....	264,625	120,929	66,032	20,672	27,491	77,664	45.7	25.0	54.6	58.7
Wagoner.....	270,471	120,494	74,783	32,211	23,010	19,562	68,194	47.1	27.6	58.7
Washington.....	122,366	36,046	43,202	8,476	13,341	21,385	23,148	45.8	35.3	77.1
Washita.....	613,819	294,982	183,655	42,995	24,529	116,131	135,182	48.1	29.9	62.3
Woods.....	655,921	210,589	327,863	68,372	21,798	237,693	87,469	36.7	50.0	136.3
Woodward.....	619,933	290,283	261,707	81,475	92,568	81,664	157,943	32.3	42.2	130.7
Total.....	28,859,333	12,092,476	10,013,450	2,581,390	3,008,187	4,423,873	6,733,427	41.8	34.7	82.8

TABLE II.—*Pasture land on farms in the United States, by counties (1910 census)*—Continued.

County.	Total land in farms.	Land in crops.	Pasture land.					All other farm land.	Percentage of total farm land devoted to—		Acres in pasture per 100 acres in crops.	
			Total.			Other.			Crops.	Pasture.		
			Total.	Improved.	Woodland.							
OREGON.												
Baker.....	297,695	89,324	136,552	38,549	17,065	80,938	71,819	30.0	45.8	152.9		
Benton.....	235,504	53,176	103,337	5,192	64,023	26,122	76,991	22.6	44.7	198.1		
Blackman.....	301,069	81,311	127,485	5,665	73,332	48,488	92,913	27.0	42.4	156.8		
Clatsop.....	54,221	5,293	32,696	7,618	17,166	7,912	16,232	9.7	60.3	617.7		
Columbia.....	91,372	10,540	36,958	1,246	21,308	14,404	43,874	11.5	40.4	350.6		
Coos.....	202,102	15,618	117,136	11,988	59,369	45,779	69,348	7.7	58.0	750.0		
Crook.....	571,600	79,559	355,376	58,444	238,753	73,553	136,665	13.9	62.2	446.7		
Curry.....	106,772	3,856	71,650	10,194	10,557	10,305	31,805	3.6	66.5	1,842.5		
Douglas.....	577,428	68,434	241,527	49,984	109,531	82,012	267,407	11.9	41.8	332.9		
Gilliam.....	434,277	110,672	185,153	15,272	8,661	161,220	129,452	27.6	42.6	154.7		
Graham.....	445,170	39,106	284,819	20,308	51,081	213,430	121,245	8.6	64.0	128.3		
Grant.....	562,204	75,342	117,125	40,400	4,705	72,020	369,737	13.4	20.8	155.5		
Harney.....	38,049	14,284	4,419	379	3,552	488	19,346	37.5	11.6	30.9		
Hood River.....	297,171	68,528	89,866	7,084	61,222	21,560	138,777	23.1	39.2	131.1		
Jackson.....	121,845	16,966	19,902	2,342	14,666	2,894	81,977	16.3	16.3	117.3		
Josephine.....	434,340	77,885	162,857	54,608	38,341	69,818	213,598	17.1	35.8	209.1		
Klamath.....	401,555	64,844	203,013	33,406	26,291	143,316	133,698	16.1	50.6	313.1		
Lake.....	485,265	95,989	228,634	24,517	120,871	83,213	169,642	19.8	47.1	238.2		
Lane.....	158,282	7,050	67,110	3,467	43,505	20,138	84,122	4.5	42.4	951.9		
Lincoln.....	462,337	132,513	202,470	52,861	65,564	84,015	127,334	28.7	43.8	132.8		
Linn.....	230,175	52,314	90,969	10,368	5,793	74,808	86,802	22.7	39.5	173.8		
Malheur.....	394,115	145,812	153,728	17,806	90,607	45,315	94,875	37.0	39.0	105.4		
Marion.....	673,907	102,680	334,335	42,126	64,486	227,723	237,032	15.2	49.6	325.8		
Morrow.....	86,262	25,244	32,312	3,395	15,623	13,394	28,706	29.3	37.5	128.0		
Multnomah.....	269,367	82,984	101,485	11,421	66,582	23,482	75,898	31.9	39.0	122.3		
Polk.....	372,926	142,944	91,762	3,352	2,980	85,430	137,820	38.4	24.6	64.2		
Sherman.....	91,493	17,415	31,514	8,139	16,422	9,953	48,564	12.1	36.5	302.4		
Tillamook.....	1,050,258	267,718	375,990	47,744	73,736	252,520	406,550	25.5	38.8	140.4		
Umatilla.....	395,769	110,239	218,324	17,185	82,468	118,871	66,986	27.9	55.2	198.2		
Union.....	354,732	58,777	221,256	17,772	70,845	112,639	74,699	16.6	62.4	376.4		
Walla.....	543,754	89,794	321,295	32,641	73,209	215,445	132,665	16.5	59.1	357.8		
Wasco.....	240,328	87,187	75,493	5,021	55,860	31,612	77,648	36.3	31.4	86.6		
Washington.....	415,576	20,658	383,973	33,508	71,916	215,549	71,916	4.8	92.4	1,914.3		
Wheeler.....	274,260	90,476	122,331	12,446	66,799	43,086	61,453	33.0	44.6	135.2		
Yamhill.....												
Total.....	11,685,110	2,406,932	5,347,452	716,273	1,668,467	2,962,712	3,930,726	20.6	45.8	222.2		

PENNSYLVANIA.

Adams.....	281,858	184,831	35,800	13,521	12,303	61,224	65.6	12.7	19.4
Allegheny.....	308,312	138,263	78,509	44,030	26,810	91,570	44.8	25.5	56.8
Armstrong.....	355,413	131,573	81,350	57,081	20,406	136,330	37.9	23.7	62.7
Beaver.....	229,768	183,705	59,830	30,120	21,320	89,253	30.4	24.7	67.9
Bedford.....	403,916	117,322	121,813	60,067	52,213	196,780	31.6	26.1	82.7
Berks.....	458,450	311,447	33,520	14,519	8,097	110,483	68.6	7.3	10.7
Blair.....	176,513	77,486	30,705	8,967	17,721	68,322	43.9	17.4	39.6
Bradford.....	623,303	242,758	185,668	108,092	41,599	194,877	38.9	29.8	76.5
Bucks.....	323,928	226,230	41,116	11,681	16,806	85,582	64.1	11.6	18.2
Butler.....	413,107	170,010	106,303	50,731	42,817	136,791	41.1	25.7	62.6
Cambria.....	228,001	82,338	52,207	12,218	28,939	93,459	36.1	22.9	63.4
Cameron.....	31,748	6,182	10,086	1,394	4,578	18,480	17.8	29.0	103.2
Carbon.....	96,303	30,270	17,679	1,633	13,953	48,351	31.4	18.4	58.4
Center.....	286,822	134,697	47,792	14,539	25,562	2,063	47.0	16.7	35.5
Chester.....	423,827	225,276	74,900	38,124	12,031	104,333	53.2	17.7	33.2
Clarion.....	272,715	118,884	64,720	19,610	30,779	123,642	43.1	21.7	51.7
Clearfield.....	271,091	96,041	57,502	15,503	36,193	117,551	35.3	21.2	53.9
Clinton.....	130,619	48,027	19,246	5,110	12,895	53,346	38.8	16.0	40.1
Columbia.....	228,039	123,283	15,485	6,731	6,961	89,291	34.0	6.8	12.6
Crawford.....	263,411	223,577	230,558	59,157	99,483	126,276	38.5	39.7	103.1
Cumberland.....	214,300	135,808	16,738	6,852	4,559	63,708	70.4	3.4	7.7
Dauphin.....	76,032	38,012	20,141	13,127	3,554	4,559	63.8	7.8	12.3
Delaware.....	82,575	23,780	22,467	3,662	13,894	29,785	31.3	29.5	91.5
Elk.....	417,601	203,785	167,329	38,250	69,174	39,945	45.5	33.7	102.3
Erie.....	318,475	104,828	107,249	56,759	37,841	106,398	32.9	37.4	82.3
Fayette.....	49,221	13,041	11,559	1,615	8,471	24,621	26.5	23.5	88.6
Forest.....	385,331	232,962	39,141	15,527	15,918	113,228	60.5	10.2	16.8
Franklin.....	196,858	58,010	23,683	13,031	7,546	115,165	29.5	12.0	40.8
Fulton.....	330,570	112,861	169,109	173,297	20,000	42,480	31.8	56.2	176.5
Greene.....	310,539	105,267	78,838	27,668	44,372	156,431	30.9	23.2	74.9
Huntingdon.....	422,977	139,986	60,560	60,560	31,795	171,365	37.0	23.5	63.5
Indiana.....	249,189	106,696	56,189	18,631	28,469	86,004	42.9	22.5	52.5
Jefferson.....	173,136	73,798	22,868	7,351	11,489	76,470	42.6	13.4	31.0
Juniata.....	131,163	43,214	46,347	7,652	25,230	44,599	32.2	34.5	107.2
Lackawanna.....	530,499	388,235	74,544	36,111	17,066	87,720	70.5	26.3	55.6
Lancaster.....	193,702	91,888	51,051	17,272	20,625	50,820	47.4	26.3	11.0
Lawrence.....	173,563	126,938	13,905	5,003	5,732	32,750	73.1	8.0	9.7
Lebanon.....	191,657	140,235	13,537	9,831	1,641	37,885	73.2	7.1	9.7
Lehigh.....	269,486	89,575	43,503	11,654	21,631	136,408	33.2	16.1	48.6
Luzerne.....	358,209	149,907	56,042	14,238	39,781	152,200	41.8	15.6	37.4
Lycoming.....	159,150	40,720	66,353	9,700	31,451	25,202	41.7	41.7	162.9
McKean.....	389,208	164,003	127,891	41,568	56,082	97,314	42.1	32.9	78.0
Mercer.....	113,719	68,258	25,455	5,901	11,419	50,006	47.5	17.7	37.3
Millin.....	204,077	58,375	36,937	11,580	18,076	108,745	28.6	18.1	63.3
Monroe.....	251,751	166,317	28,804	13,684	8,305	56,680	66.1	11.4	17.3
Montgomery.....	74,510	48,571	6,742	2,253	3,700	19,227	65.2	9.0	13.9
Northampton.....	192,651	131,277	19,083	10,226	3,310	39,291	63.7	9.9	14.2

TABLE II.—*Pasture land on farms in the United States, by counties (1910 census)*—Continued.

County.	Total land in farms.	Land in crops.	Pasture land.				All other farm land.	Percentage of total farm land devoted to—		Acres in pasture per 100 acres in crops.
			Total.	Improved.	Woodland.	Other.		Crops.	Pasture.	
PENNSYLVANIA—Continued.										
Northumberland.....	211,583	127,045	11,702	5,079	4,140	2,543	72,776	60.0	5.6	9.3
Perry.....	250,118	105,652	25,975	9,541	12,459	3,975	118,491	42.2	10.4	24.6
Philadelphia.....	30,488	18,057	3,915	2,016	1,024	8,875	8,486	39.3	12.8	21.6
Pike.....	173,481	15,172	23,789	5,256	12,492	6,051	134,510	8.7	13.7	156.9
Potter.....	271,217	78,549	101,870	16,239	51,170	31,461	90,798	29.0	37.6	129.7
Schuylkill.....	216,318	107,885	14,660	5,518	6,287	2,855	38,803	49.9	6.8	13.6
Snyder.....	151,922	85,331	15,751	9,094	4,459	2,198	50,840	56.2	10.4	18.5
Somerset.....	475,258	152,702	151,455	42,126	76,032	33,297	171,101	32.1	31.9	99.2
Sullivan.....	98,216	28,471	36,610	3,715	14,810	18,085	31,135	29.6	38.0	128.6
Susquehanna.....	472,428	139,889	178,104	76,574	46,600	54,430	144,435	31.7	37.7	118.8
Toga.....	473,471	177,296	158,735	53,801	64,839	40,095	139,440	37.3	33.4	89.5
Union.....	108,730	74,832	9,933	3,212	5,186	1,535	24,025	68.8	9.1	13.3
Venango.....	216,367	85,519	67,780	18,096	33,885	13,799	83,068	34.7	27.5	79.3
Warren.....	254,321	66,191	98,662	20,826	46,476	31,360	83,468	26.0	38.8	149.1
Washington.....	503,923	192,789	224,187	174,146	33,690	16,351	86,947	38.3	44.5	116.3
Wayne.....	373,557	91,600	151,571	17,919	41,455	89,197	132,386	24.4	40.4	165.5
Westmoreland.....	493,491	208,497	137,014	79,990	36,567	20,487	147,950	42.2	27.8	65.7
Wyoming.....	169,031	51,050	52,448	27,658	13,313	11,477	62,533	32.0	31.0	97.0
York.....	532,017	331,113	29,480	13,558	8,002	7,220	171,424	62.2	5.5	8.9
Total.....	18,586,832	8,224,299	4,350,126	1,798,923	1,612,309	938,894	6,012,407	44.2	23.4	52.9
RHODE ISLAND.										
Bristol.....	9,551	3,770	2,667	865	1,254	548	3,114	39.5	27.9	70.7
Kent.....	68,956	19,748	24,021	6,679	12,213	5,129	35,187	14.1	34.8	246.4
Newport.....	47,240	9,338	14,228	7,718	3,304	3,116	13,674	40.9	30.1	73.6
Providence.....	166,343	34,667	36,285	7,150	21,089	8,046	92,991	20.5	21.8	106.5
Washington.....	151,218	24,100	51,563	17,222	21,926	12,255	75,615	15.9	34.1	213.7
Total.....	443,308	91,023	128,704	34,734	59,876	29,094	223,581	20.5	23.0	141.4

Abeville.....	378,544	152,665	45,481	5,961	21,211	10,309	130,098	40.4	12.0	29.8
Aiken.....	438,581	193,438	16,601	3,125	11,072	2,404	28,472	42.2	3.6	8.6
Anderson.....	444,606	231,593	43,931	5,790	28,687	9,454	169,082	52.1	9.9	19.0
Bamberg.....	192,451	106,147	8,095	933	7,458	304	83,609	52.0	4.5	8.7
Beaufort.....	408,697	219,073	8,162	933	7,458	711	181,462	53.6	2.0	3.7
Berkeley.....	188,914	65,389	21,269	2,790	8,582	1,104	111,256	34.6	6.5	18.8
Calhoun.....	348,516	64,664	20,386	2,741	16,541	1,104	263,466	18.6	5.8	31.5
Charleston.....	176,414	83,418	7,001	678	6,121	2,433	85,995	27.3	4.0	8.4
Cherokee.....	141,313	35,104	3,230	3,230	29,441	2,433	101,239	47.3	19.8	65.0
Chester.....	216,606	77,802	28,467	2,638	21,188	8,553	110,337	35.9	13.5	36.6
Chesterfield.....	312,751	110,152	48,572	7,767	32,252	4,641	154,027	35.2	15.1	44.1
Cherokee.....	371,699	101,063	23,949	1,825	19,709	4,915	246,657	27.2	3.0	23.7
Clarendon.....	255,956	136,799	12,849	1,404	6,488	4,917	106,288	53.5	5.0	9.4
Colleton.....	471,013	120,836	123,342	17,656	90,621	15,065	226,835	25.7	26.2	102.1
Darlington.....	255,433	143,855	8,860	1,414	6,745	15,707	102,712	56.3	3.5	6.2
Dillon.....	175,476	84,990	18,294	963	13,039	1,636	72,262	48.4	10.4	21.5
Dorchester.....	196,291	51,798	14,270	337	18,317	3,805	129,060	25.8	9.0	27.5
Edgefield.....	296,357	144,700	26,597	4,475	43,636	12,249	203,329	32.3	16.6	51.3
Fairfield.....	397,885	128,644	65,912	10,027	7,967	482	167,973	38.5	6.3	16.3
Florence.....	304,299	117,218	19,108	1,569	34,236	13,994	184,212	39.0	10.1	116.8
Georgetown.....	226,873	19,678	22,983	1,022	35,783	8,783	292,792	32.3	12.2	31.4
Greenville.....	415,795	162,106	50,897	7,878	33,802	3,832	111,604	46.0	15.3	33.3
Greenwood.....	288,949	133,025	44,320	4,621	27,802	3,832	254,585	28.6	7.5	26.1
Hampton.....	398,254	113,895	29,774	1,791	25,459	620	331,327	17.1	6.4	31.7
Horry.....	427,322	72,872	23,123	44	15,429	1,246	192,865	32.5	6.3	19.7
Kershaw.....	315,513	102,505	20,143	3,468	12,734	7,612	155,507	34.8	8.3	23.9
Lancaster.....	273,456	95,186	22,763	2,417	21,153	11,017	170,273	43.0	12.2	28.4
Laurens.....	380,363	163,608	46,422	8,252	2,589	808	95,628	54.7	1.7	3.0
Lee.....	219,178	119,890	3,660	2,263	38,556	3,907	265,403	31.3	10.0	31.9
Lexington.....	451,720	141,226	45,061	2,598	9,073	92	121,047	35.1	47.0	13.4
Marion.....	201,159	70,644	9,448	283	2,669	1,807	96,907	55.5	2.4	4.3
Marlboro.....	230,322	127,973	5,471	995	26,251	3,051	145,344	43.3	10.8	24.9
Newberry.....	316,355	136,913	34,098	4,796	32,173	5,362	211,954	25.1	12.2	48.5
Oconee.....	337,878	84,812	41,112	3,577	29,003	1,061	225,422	50.9	6.3	12.4
Orangeburg.....	327,861	268,695	33,244	3,180	19,485	3,312	144,386	31.9	10.4	32.6
Pickens.....	250,143	79,769	25,988	3,191	14,899	3,244	105,080	41.0	8.3	20.3
Richland.....	207,361	85,163	17,318	2,175	21,909	1,757	115,009	43.7	10.9	24.9
Saluda.....	254,249	111,174	27,666	4,000	36,309	5,130	166,753	44.0	11.8	26.7
Spartanburg.....	445,277	196,076	52,448	6,989	3,270	1,217	121,008	52.4	2.6	4.9
Sumter.....	268,490	140,571	6,911	7,661	20,602	6,002	124,369	36.9	13.6	37.0
Union.....	251,316	92,682	34,265	7,661	52,194	2,950	216,169	34.6	13.4	38.8
Williamsburg.....	413,912	143,942	53,801	7,661	30,059	8,167	173,486	42.3	12.1	28.6
York.....	380,777	161,151	46,140	7,914	30,059	8,167	173,486	42.3	12.1	28.6
Total.....	13,512,028	5,193,174	1,286,912	154,452	953,086	179,374	7,031,942	38.4	9.5	24.8

TABLE II.—*Pasture land on farms in the United States, by counties (1910 census)*—Continued.

County.	Total land in farms.	Land in crops.	Pasture land.				All other farm land.	Percentage of total farm land voted to—		Acres in pasture per 100 acres in crops.
			Total.	Improved.	Woodland.	Other.		Crops.	Pasture.	

SOUTH DAKOTA.										
Armstrong.....	174,657	7,961	20,793	1,180	1,105	145,903	4.6	11.9	261.2	
Aurora.....	357,368	191,371	114,578	23,548	1,641	89,389	53.6	32.1	59.9	
Beadle.....	677,719	355,024	183,714	137,914	2,282	43,518	52.4	27.1	51.7	
Bennett.....	109,850	18,664	16,759	10,178	15,320	36,261	17.7	15.3	89.8	
Bonhomme.....	348,803	222,229	89,546	37,469	15,431	36,646	63.7	25.7	40.3	
Brookings.....	473,816	288,385	83,085	52,088	7,774	23,223	60.9	17.5	28.8	
Brown.....	973,595	663,357	162,676	92,088	5,531	65,137	71.2	16.7	23.5	
Brule.....	407,920	187,221	182,705	119,589	6,426	56,690	45.9	44.8	97.6	
Buffalo.....	113,349	31,876	48,935	6	287	48,642	28.1	43.2	15.4	
Butte.....	238,527	37,383	107,302	3,354	4,461	99,487	15.7	44.9	287.0	
Campbell.....	391,268	173,944	151,888	51,544	2,655	97,689	65.4	38.8	87.2	
Charles Mix.....	548,926	332,816	136,912	54,623	11,275	71,014	60.6	24.9	41.1	
Clark.....	552,475	370,880	105,490	65,662	1,295	38,533	67.1	19.1	28.4	
Clay.....	244,172	165,340	50,810	33,996	4,473	12,341	28.0	67.7	31.7	
Codington.....	400,987	278,870	62,916	28,378	9,315	25,223	68.0	15.3	22.6	
Corson.....	508,698	25,644	241,197	127,574	3,363	113,260	5.0	47.4	940.6	
Custer.....	282,345	42,679	189,234	14,000	14,288	160,946	50.4	67.0	443.4	
Daivison.....	257,762	155,269	63,567	38,527	1,417	25,623	60.2	24.7	40.9	
Day.....	628,805	380,376	122,631	63,611	4,271	54,749	115.7	16.9	31.4	
Deuel.....	330,819	166,919	55,762	26,743	1,016	25,003	108.1	50.5	33.4	
Dewey.....	130,476	2	90,162	9,836	4,236	76,090	40.3	68.1	4.0	
Douglas.....	259,777	153,243	61,379	10,960	200	50,219	45.1	59.0	58.5	
Edmunds.....	236,770	236,770	138,237	77,129	11,937	49,171	59.0	31.9	40.1	
Fall River.....	34,315	34,315	187,177	29,851	13,878	143,448	175.7	47.1	54.5	
Faulk.....	436,042	259,495	114,219	86,696	1,448	26,075	62.3	26.2	44.0	
Grant.....	382,881	258,453	64,744	18,937	9,654	36,153	59.5	16.9	25.1	
Gregory.....	471,142	216,776	171,304	43,331	10,761	117,912	46.0	36.4	79.0	
Hamlin.....	234,416	207,189	45,614	32,078	1,704	11,832	41.6	15.5	22.0	
Hanson.....	672,808	323,373	216,081	148,931	6,247	60,903	131.4	48.4	66.4	
Harding.....	255,944	165,343	58,339	19,688	3,631	35,220	65.8	22.9	34.8	
Hughes.....	235,133	27,513	121,301	29,110	4,110	87,281	11.7	51.2	438.0	
Hutchinson.....	165,069	46,829	96,153	34,012	3,522	58,619	28.4	58.3	205.3	
Hwyden.....	501,556	333,896	121,748	53,508	4,069	63,141	49.9	24.1	102.5	
Hyde.....	212,208	89,670	92,106	33,391	3,158	55,557	42.3	36.2	67.7	
Jerold.....	283,685	152,252	102,706	49,404	878	52,424	53.7	36.2	67.7	

Kingsbury.....	489,082	330,146	75,051	32,717	2,176	40,158	83,885	67.5	15.3	22.7
Lake.....	339,696	221,839	56,533	35,882	2,683	14,966	61,324	63.3	16.6	25.5
Lawrence.....	124,626	35,145	65,873	5,990	12,468	47,415	23,608	28.2	20.4	187.4
Lincoln.....	360,199	255,266	73,462	44,744	9,601	19,117	31,471	70.9	20.4	28.8
Lyman.....	977,345	244,457	403,360	142,467	37,586	283,307	199,528	26.9	51.1	189.5
McCook.....	341,263	238,113	69,386	37,496	3,655	28,835	33,764	69.8	20.3	29.1
McPherson.....	437,513	220,826	137,709	50,480	17,940	69,289	78,978	50.5	31.5	62.4
Marshall.....	469,601	298,739	134,750	75,677	7,292	51,781	36,112	63.6	28.7	45.1
Meade.....	913,943	141,525	487,743	114,839	24,191	348,653	284,675	15.5	53.4	344.1
Mellette.....	84,289	5,787	81,105	6,572	4,723	69,810	(a)	6.9	96.2	1,401.6
Miner.....	330,006	199,175	69,540	48,016	1,510	19,414	61,491	60.4	21.1	34.5
Mitchell.....	405,610	357,089	93,086	64,989	8,010	20,087	45,435	72.1	18.8	26.9
Moody.....	308,478	213,944	57,209	39,440	2,923	15,437	37,325	69.4	18.5	26.7
Pennington.....	626,946	122,494	337,621	106,354	23,243	206,024	166,831	19.5	53.9	273.6
Perkins.....	670,398	176,386	173,838	4,378	4,378	167,863	420,373	11.4	23.9	227.6
Potter.....	364,011	154,506	190,178	83,570	24,896	76,712	19,327	67.4	52.2	123.1
Roberts.....	379,760	388,602	80,346	32,720	1,334	46,232	110,812	42.0	13.9	20.7
Sanborn.....	325,869	185,085	87,355	32,224	1,412	53,719	53,429	56.8	26.8	47.2
Schlesse.....	60,900						60,900			
Shannon.....	243,921	13,147	129,412	56,732	701	71,979	101,362	5.4	53.1	984.3
Spink.....	854,469	614,004	150,226	97,730	4,641	47,855	99,239	71.9	17.6	24.5
Stanley.....	1,174,435	278,807	503,397	119,275	7,872	406,250	302,231	23.7	50.5	212.8
Stearns.....	55,540	2,007	1,275	640	475	160	52,258	3.6	23.0	63.5
Sterling.....	323,310	109,573	170,971	25,819	25,211	119,911	42,763	33.9	52.9	156.0
Sully.....	41,351	4,771	9,771	9,915	25,819	8,011	(a)	42.0	86.1	294.9
Todd.....	423,631	46,124	120,721	12,092	6,127	102,555	256,756	10.9	28.5	231.7
Tripp.....	374,235	239,216	82,988	43,511	3,335	36,153	32,621	60.3	22.2	72.0
Turner.....	267,107	189,892	45,702	31,099	7,051	7,552	31,543	71.1	17.1	21.1
Union.....	331,606	183,027	107,897	16,999	6,102	81,886	40,682	53.2	32.5	59.0
Walworth.....	70,160	4,318	1,390	1,290	80	20	61,452	6.2	2.0*	32.2
Washburn.....	185,682	13,574	46,118	6,124	440	39,551	125,990	7.3	24.8	339.8
Washington.....	307,928	192,239	81,168	33,352	11,819	38,997	31,521	62.4	27.3	43.8
Yankton.....										
Total.....	26,016,892	12,243,060	8,148,371	3,006,616	442,874	4,638,881	5,625,461	47.1	31.3	66.6

TENNESSEE.

Anderson.....	162,660	40,040	21,967	14,512	4,167	3,288	100,653	24.6	13.5	54.9
Bedford.....	291,673	115,289	103,811	20,445	63,517	7,799	75,573	39.5	34.6	87.4
Benton.....	229,506	48,504	18,737	4,506	10,116	4,025	162,325	21.1	8.2	38.6
Bledsoe.....	134,751	27,913	11,051	3,239	1,145	610	95,754	20.7	8.7	39.6
Blount.....	229,169	79,399	42,752	28,978	10,671	3,163	107,018	34.0	18.7	53.8
Bradley.....	188,483	51,537	36,376	16,751	16,873	2,732	100,570	27.1	19.3	70.6
Campbell.....	137,297	37,178	21,872	14,718	5,060	2,694	78,237	27.1	15.9	58.8
Cannon.....	159,876	47,829	41,217	13,520	25,037	2,660	70,830	29.9	25.8	86.2
Carroll.....	338,919	110,651	42,821	9,978	21,220	11,922	185,414	32.7	12.6	38.7
Carter.....	133,717	39,014	21,544	13,798	6,824	1,922	73,159	29.2	16.1	55.2
Cheatham.....	143,759	36,914	10,468	4,124	6,640	1,701	93,377	25.7	7.3	28.4
Chester.....	178,067	38,465	21,279	3,165	13,062	5,052	98,323	24.3	13.5	55.3

a See table of counties reporting an excessive acreage in pasture, on page 13.

TABLE II.—*Pasture land on farms in the United States, by counties (1910 census)*—Continued.

County.	Total land in farms.	Land in crops.	Pasture land.				All other farm land.	Percentage of total farm land de- voted to—		Acres in pasture per 100 acres in crops.
			Total.	Improved.	Woodland.	Other.		Crops.	Pasture.	
TENNESSEE—Continued.										
Claiborne.....	232,625	58,890	44,493	25,748	9,395	9,350	129,242	25.3	19.1	75.6
Clay.....	155,822	35,389	12,587	5,978	5,262	5,262	107,556	22.7	8.1	35.6
Cocke.....	208,753	61,663	38,148	24,093	8,577	8,577	108,942	29.5	18.3	61.9
Coffee.....	189,516	56,233	31,961	13,551	13,410	13,410	101,922	29.7	16.9	56.8
Crockett.....	145,613	79,968	19,215	6,749	10,940	1,526	46,430	54.9	13.2	21.0
Cumberland.....	117,441	18,138	5,751	1,191	4,513	1,530	86,349	15.4	4.9	31.7
Davidson.....	289,405	100,726	97,737	21,824	70,148	5,773	90,922	34.8	33.8	97.1
Decatur.....	174,937	39,092	9,884	2,574	5,583	1,727	125,961	22.4	3.7	25.3
DeKalb.....	197,912	64,500	54,577	17,680	29,727	7,170	78,825	32.6	27.6	84.6
Dickson.....	249,046	62,140	27,687	17,256	7,315	3,116	159,219	24.9	11.1	17.9
Dyer.....	232,717	116,986	20,994	7,724	12,045	1,225	64,737	57.7	10.4	44.6
Fayette.....	358,017	159,527	71,941	32,048	30,893	9,000	126,549	44.6	20.1	45.1
Fentress.....	143,973	19,719	11,074	5,785	4,757	532	113,180	13.7	7.7	56.2
Franklin.....	226,488	83,420	27,965	19,729	6,695	1,541	115,103	36.8	12.3	33.5
Gibson.....	311,305	165,141	67,865	23,662	37,592	6,611	108,299	48.4	19.9	41.1
Giles.....	357,722	136,851	100,069	57,627	28,422	14,050	120,772	38.3	28.0	73.1
Graham.....	187,061	54,491	47,446	34,020	8,987	4,939	85,124	29.1	25.4	87.1
Greene.....	354,421	127,830	78,887	64,675	10,223	3,989	147,704	22.2	22.2	61.8
Grundy.....	68,906	12,181	1,521	813	485	223	55,204	17.7	2.2	12.5
Hamblen.....	106,935	41,993	27,837	22,394	3,430	2,013	37,105	39.3	26.0	66.3
Hamilton.....	122,969	40,661	11,365	6,454	4,252	889	70,653	33.1	9.4	28.5
Hancock.....	131,440	32,259	26,913	17,453	5,832	3,628	72,268	24.6	20.5	83.4
Hardeman.....	346,428	92,394	65,801	27,463	33,835	9,503	188,233	26.7	19.0	21.6
Hardin.....	276,149	71,047	15,992	3,418	11,026	1,548	186,110	26.8	3.8	71.2
Hawkins.....	297,432	79,963	76,431	58,957	6,548	10,926	141,638	26.9	25.7	95.6
Haywood.....	249,615	127,756	39,715	14,920	23,940	855	82,144	51.2	13.9	31.1
Henderson.....	305,911	71,186	31,762	6,911	21,317	3,534	202,963	23.3	10.4	44.6
Henry.....	342,583	100,441	37,445	13,753	18,121	5,571	204,697	24.3	10.9	37.3
Hickman.....	250,807	56,151	18,056	11,882	5,209	965	176,600	22.4	7.2	32.2
Houston.....	81,792	16,875	6,662	3,804	2,173	a 685	58,255	20.6	8.1	39.4
Humphreys.....	226,413	53,110	13,697	7,846	4,878	973	159,606	23.5	6.0	25.8
Jackson.....	181,809	57,208	37,613	8,952	22,594	6,067	86,988	31.5	20.7	65.7
James.....	84,959	27,253	9,665	3,983	4,915	6,017	53,011	26.2	11.4	43.4
Jefferson.....	184,130	77,294	37,313	23,438	4,541	7,334	69,523	42.0	20.3	48.3
Johnson.....	119,564	27,482	20,260	20,260	3,509	1,323	66,960	23.1	21.0	91.3
Knox.....	285,344	103,015	59,906	36,011	1,015	5,890	122,423	36.1	21.0	58.2
Lake.....	58,469	41,202	853	272	504	79	15,352	75.7	1.5	1.9

Landerdale.....	214, 702	96, 131	16, 578	2, 151	11, 322	3, 105	101, 993	44.8	7.7	17.2
Lawrence.....	235, 790	48, 605	22, 880	8, 798	11, 120	2, 962	164, 304	20.6	9.7	47.1
Lewis.....	67, 314	11, 364	2, 181	2, 181	685	415	53, 789	16.9	3.2	19.2
Lincoln.....	322, 813	124, 299	110, 225	41, 069	59, 141	9, 472	88, 289	38.5	34.1	88.7
London.....	141, 110	42, 963	28, 802	21, 231	18, 985	12, 985	69, 375	30.4	30.4	67.0
McMinn.....	263, 461	76, 269	57, 782	25, 221	17, 649	4, 612	129, 410	23.3	21.9	42.3
McNairy.....	279, 754	65, 285	27, 030	13, 321	11, 500	2, 069	186, 826	28.4	14.6	51.5
Macon.....	184, 963	62, 478	27, 630	13, 321	38, 524	11, 704	105, 455	37.3	20.9	56.1
Madison.....	308, 615	115, 276	64, 641	13, 413	38, 524	11, 704	128, 740	37.3	20.9	56.1
Marion.....	121, 045	29, 550	13, 316	3, 433	7, 719	3, 433	78, 179	21.4	11.0	45.1
Marshall.....	227, 359	89, 556	13, 316	3, 433	32, 543	10, 428	53, 872	39.2	37.1	94.6
Maury.....	365, 321	162, 797	84, 411	21, 440	52, 543	10, 428	80, 789	44.6	33.3	71.8
Meigs.....	125, 084	32, 919	47, 192	4, 192	56, 172	15, 371	72, 106	26.3	16.0	60.9
Monroe.....	255, 217	73, 176	42, 196	26, 909	11, 428	3, 859	139, 875	28.7	16.5	57.7
Montgomery.....	324, 711	100, 514	60, 178	27, 440	23, 740	8, 998	161, 019	31.0	18.5	59.9
Moore.....	68, 249	24, 352	20, 488	11, 110	7, 831	1, 544	23, 409	35.7	30.0	84.1
Morgan.....	116, 914	19, 496	4, 083	1, 762	7, 831	1, 544	93, 335	16.7	3.5	20.9
Obion.....	307, 621	154, 271	47, 712	20, 977	7, 716	6, 065	103, 605	50.2	15.5	30.7
Overtown.....	214, 801	51, 094	24, 382	10, 772	9, 590	4, 011	139, 325	23.8	11.4	47.7
Perry.....	185, 585	29, 985	7, 753	2, 867	1, 558	3, 388	51, 778	23.0	9.9	43.0
Pickett.....	77, 168	17, 761	7, 629	3, 419	6, 884	1, 348	65, 274	24.6	10.0	40.6
Polk.....	99, 795	24, 549	9, 972	2, 540	3, 250	3, 904	130, 067	27.0	13.7	50.6
Putnam.....	219, 453	59, 311	30, 045	12, 902	13, 239	3, 904	130, 067	27.0	13.7	50.6
Rhea.....	122, 870	39, 627	20, 941	6, 674	3, 250	3, 904	130, 067	27.0	13.7	50.6
Roane.....	203, 497	53, 367	20, 982	13, 339	6, 021	1, 622	129, 148	26.2	10.3	38.3
Robertson.....	295, 651	116, 786	42, 318	26, 090	10, 887	5, 371	136, 517	39.5	14.3	36.3
Rutherford.....	363, 823	150, 770	126, 042	33, 840	81, 234	10, 968	87, 011	41.4	34.6	83.6
Scott.....	132, 081	19, 946	8, 000	4, 016	3, 393	591	104, 135	15.1	6.1	40.1
Sequatchie.....	54, 750	12, 877	5, 971	2, 749	2, 101	1, 121	35, 902	25.5	10.9	46.4
Sevier.....	286, 370	81, 558	39, 863	32, 253	2, 737	4, 873	164, 949	28.5	13.9	48.9
Shelby.....	344, 670	189, 426	67, 713	21, 006	39, 374	6, 733	87, 531	55.0	19.6	35.8
Smith.....	202, 928	78, 972	76, 208	20, 431	47, 055	8, 722	47, 718	38.9	37.6	98.5
Stewart.....	199, 639	50, 877	17, 613	10, 057	5, 745	1, 811	131, 149	25.5	8.8	31.6
Sullivan.....	228, 674	75, 154	57, 775	43, 052	11, 712	3, 011	93, 715	32.9	25.3	76.9
Sumner.....	325, 990	112, 013	54, 270	46, 008	28, 083	11, 735	101, 849	34.4	34.3	100.3
Tipton.....	237, 578	131, 873	87, 715	7, 942	12, 785	3, 938	17, 434	40.0	15.9	87.0
Trousdale.....	69, 102	27, 631	27, 637	7, 942	12, 785	3, 938	17, 434	40.0	15.9	87.0
Union.....	49, 876	10, 555	7, 418	4, 331	2, 537	5, 960	31, 503	22.0	14.9	67.7
Van Buren.....	148, 468	41, 697	36, 827	25, 927	5, 960	4, 940	69, 944	28.1	24.8	88.3
Warren.....	50, 815	9, 708	1, 599	1, 599	355	1, 793	39, 508	19.1	3.1	16.5
Washington.....	240, 834	72, 788	33, 468	15, 921	15, 754	1, 793	134, 614	30.2	13.9	46.0
Wayne.....	180, 334	73, 720	39, 505	31, 007	5, 077	3, 421	67, 109	40.9	21.9	53.6
Weakley.....	229, 036	38, 229	13, 819	9, 015	2, 368	2, 436	176, 988	16.7	6.0	36.1
Wetzel.....	332, 809	133, 246	45, 185	23, 035	18, 641	3, 509	154, 378	40.0	13.6	33.9
White.....	175, 245	54, 059	36, 297	18, 824	13, 698	3, 775	84, 889	30.9	20.7	67.1
Williamson.....	323, 168	124, 272	100, 685	28, 161	62, 653	9, 871	98, 211	38.5	31.2	81.0
Wilson.....	354, 642	121, 201	150, 540	21, 293	115, 973	13, 274	82, 901	34.2	42.5	124.2
Total.....	20, 041, 657	6, 596, 175	3, 664, 451	1, 632, 552	1, 624, 215	407, 684	9, 811, 031	32.8	18.3	55.8

a Estimated.

TABLE II.—*Pasture land on farms in the United States, by counties (1910 census)*—(Continued.)

County.	Total land in farms.	Land in crops.	Pasture land.			All other farm land.	Percentage of total farm land voted to—		Acres in pasture per 100 acres in crops.	
			Total.	Improved.	Woodland.		Other.	Crops.		Pasture.

TEXAS.									
Anderson.....	375,929	104,093	99,551	12,632	70,597	16,322	27.7	26.5	95.6
Andrews.....	342,496	226	221,950	.....	221,950	.....	1	61.8	98,208.0
Angelina.....	158,646	28,907	41,964	2,555	40,429	1,780	18.2	28.3	155.5
Aransas.....	59,436	615	58,835	9,737	7,180	41,589	1.0	99.0	9,596.7
Archer.....	443,915	38,663	381,705	103,772	138,880	23,547	8.7	86.0	1,347.2
Armstrong.....	837,729	54,796	738,194	60,429	57	608,708	6.5	88.1	1,484.3
Atascosa.....	476,906	46,807	226,690	8,763	75,912	203,409	9.8	47.5	164.5
Austin.....	100,818	100,818	165,875	58,446	53,023	54,406	29.7	48.8	6,228.1
Bailey.....	365,128	5,031	313,337	303,337	.....	10,000	1.4	85.8	1,184.8
Bandera.....	459,923	22,820	270,493	17,293	217,510	35,780	4.8	56.8	1,122.1
Bastrop.....	336,758	129,275	157,895	9,588	140,493	108,588	32.7	39.9	333.9
Baylor.....	491,218	62,343	226,839	18,490	111,249	97,140	12.7	46.2	372.9
Bee.....	432,280	56,804	212,038	10,403	184,201	103,378	13.2	49.1	332.9
Bell.....	598,303	298,915	263,728	16,363	134,545	52,804	52.6	35.8	1,608.9
Bexar.....	777,596	121,341	401,636	15,179	335,925	50,532	15.6	51.7	331.0
Brewster.....	417,964	25,171	404,977	10,777	345,917	48,283	3.6	90.4	8.2
Brown.....	271,150	8,196	247,162	57,177	158,569	131,416	23.2	59.9	257.6
Brown.....	580,098	134,781	347,162	12,030	25,025	5,510	34.3	12.7	37.2
Browne.....	334,165	114,464	42,565	13,660	37,736	67,712	16.2	47.9	296.4
Brazoria.....	119,108	40,187	119,108	15,138	91,739	7,146	38.8	40.9	105.3
Brazos.....	288,727	112,106	118,023	4,092	374,747	936,229	4.9	91.6	17,824.6
Brewster.....	112,749	7,949	1,335,068	70,523	91	361,955	12.7	92.0	1,866.9
Briscoe.....	431,078	23,653	441,568	26,051	275,279	101,184	20.9	60.5	1,299.9
Brown.....	113,270	104,706	328,389	9,404	100,646	5,353	30.6	33.7	110.2
Brown.....	341,970	116,463	116,463	13,064	359,267	77,329	32.3	77.7	63.6
Burleson.....	70,055	70,055	449,660	13,064	84,837	7,406	52.3	33.3	597.6
Burnet.....	286,578	150,013	95,340	3,097	2,181	46,592	12.7	75.8	395.5
Caldwell.....	96,231	12,199	72,902	24,129	194,829	119,353	17.5	69.0	127.9
Callahan.....	466,482	81,440	322,106	7,924	14,254	10	2.2	2.8	72.6
Callahan.....	546,004	12,137	15,623	1,259	24,139	3,096	43.5	31.6	677.2
Cameron.....	107,979	47,021	34,157	6,922	106,284	166,284	8.3	56.2	45.1
Camp.....	468,375	38,871	263,220	120,565	558	142,097	32.7	14.7	688.2
Carson.....	397,732	130,004	58,669	10,621	35,352	209,119	10.6	72.8	458.4
Cass.....	290,168	30,592	210,543	1,425	29,998	48,033	13.4	61.5	458.4
Castro.....	181,566	24,214	110,983	45,890	16,255	48,838	13.4	61.5	458.4

Cherokee.....	344,894	120,328	71,580	20,182	48,896	2,352	152,986	34.9	29.8	59.5
Childrens.....	300,570	76,278	160,956	1,387	68,608	91,011	63,336	25.4	53.5	211.0
Clay.....	719,370	164,091	361,785	149,969	54,718	137,108	193,404	22.8	50.3	220.5
Cochran.....	490,970	489,882	489,144	16,421	343,983	124,768	23,854	8.3	99.6	55,458.5
Coke.....	553,333	46,307	485,172	16,421	343,983	124,768	23,854	8.3	99.6	1,047.7
Coleman.....	718,107	160,151	506,150	52,620	313,429	140,101	45,806	23.1	70.5	304.6
Collins.....	591,855	369,282	64,703	12,224	36,997	15,482	67,870	73.6	12.9	504.8
Collingsworth.....	412,845	60,500	365,403	42,601	736	262,066	46,942	17.4	74.0	504.8
Colorado.....	383,919	95,341	219,504	51,173	111,637	56,604	69,074	24.8	57.2	230.2
Colmar.....	333,821	41,220	65,503	13,351	33,816	48,396	217,038	11.6	15.8	159.1
Conchance.....	541,475	188,279	270,048	9,288	200,499	69,261	83,148	34.8	49.9	143.4
Concho.....	588,835	58,709	529,126	124,022	208,883	61,447	85,774	40.8	73.2	671.7
Cooke.....	500,129	204,175	234,622	25,303	94,674	115,245	61,332	40.8	46.9	114.9
Corvett.....	606,516	202,413	329,922	36,142	229,639	73,141	74,181	33.4	54.4	163.0
Cottrell.....	460,439	26,393	409,332	89,116	243,602	70,614	24,714	5.7	88.9	1,550.9
Crane.....	310,362	357	306,467	1,224,562	89,550	216,937	3,558	-1	98.7	89,845.9
Crockett.....	1,369,227	606	2,132,174	418,178	1,224,562	489,434	170,033	3.6	50.6	351,813.9
Grosby.....	370,901	13,212	187,636	45,072	7,117	135,447	170,033	3.6	50.6	1,420.2
Dallam.....	346,697	22,772	294,581	268,222	61,763	26,359	29,344	6.6	85.0	1,293.6
Dallas.....	492,888	258,911	127,369	27,551	61,763	38,055	106,608	52.5	25.8	49.2
Dawson.....	177,432	12,426	128,378	84,920	6,215	37,243	36,628	7.0	72.4	1,033.1
Deaf Smith.....	273,456	31,080	170,033	148,248	21,825	6,390	12,343	11.4	62.2	517.1
Denton.....	151,773	95,872	43,140	6,947	29,803	77,827	12,761	63.2	28.1	45.0
Denton.....	540,380	262,078	183,498	131,664	77,827	71,007	94,804	48.5	34.0	70.0
Dewitt.....	545,855	136,030	363,171	25,700	251,162	88,309	44,651	21.9	66.9	268.5
Dickens.....	1,555,156	10,860	405,947	165	27,456	378,326	1,138,340	.7	26.1	3,734.9
Dimmit.....	391,745	2,515	302,609	1,676	300,868	65	186,621	.6	77.3	12,032.2
Donley.....	488,721	49,353	269,532	73,759	1,670	194,103	109,836	10.1	55.2	546.1
Duval.....	500,845	19,973	426,316	27,652	325,315	75,449	63,456	3.9	83.6	2,135.0
Eastland.....	420,137	120,712	215,113	1,272	200,289	11,552	86,312	28.7	50.7	176.5
Ector.....	452,860	2,359	111,566	b 1,577	b 2,962	b 107,027	338,955	.5	21.6	4,769.8
Edwards.....	1,489,001	5,782	1,299,240	1,049	389,916	908,275	183,979	.4	87.3	22,470.4
Ellis.....	536,139	354,838	74,911	19,233	31,085	24,503	112,390	65.3	13.9	21.3
El Paso.....	340,820	12,642	283,677	10,082	54,052	219,543	2,044,510	.5	12.1	2,243.9
Erath.....	610,358	162,753	316,309	16,748	190,162	100,359	131,296	26.7	51.8	194.3
Falls.....	240,714	88,595	12,172	12,172	59,058	17,365	77,749	59.1	21.8	36.8
Fannin.....	318,955	318,955	41,990	30,807	59,731	14,452	63,851	66.8	19.9	29.8
Fayette.....	166,345	314,441	314,441	26,900	234,611	52,930	40,343	31.9	60.3	189.0
Fisher.....	89,817	186,086	186,086	1,547	154,575	30,864	171,139	20.1	41.7	208.2
Floyd.....	37,150	119,327	2,504	2,504	115,134	70,161	121,523	11.9	38.4	321.2
Fort Bend.....	290,704	45,833	123,348	36,364	16,123	59,944	59,897	35.0	43.7	269.1
Fort Worth.....	309,654	108,358	141,399	40,298	58,098	7,047	38,139	33.5	130.5	138.5
Franklin.....	319,006	113,111	114,583	16,047	33,098	7,025	91,312	35.5	35.9	101.7
Freestone.....	635,515	8,465	457,426	9,828	359,434	69,129	136,924	9.5	69.0	728.2
Frio.....	500,772	8,465	457,426	9,828	359,434	69,129	136,924	9.5	69.0	728.2
Gaines.....	51,116	15,062	13,544	1,379	1,100	11,065	22,510	29.5	26.5	5,403.7
Galveston.....	444,683	8,809	434,891	2,955	174,373	983	50,833	2.0	97.8	4,936.9
Garza.....	669,081	58,186	580,062	4,068	435,878	120,116	50,833	8.7	83.7	962.5
Gillespie.....	356,720	6,650	305,887	550	305,337	44,783	44,783	1.7	88.7	5,056.0
Glasscock.....										

a See table of counties reporting an excessive acreage in pasture, on page 13.

b Estimated.

TABLE II.—*Pasture land on farms in the United States, by counties (1910 census)*—Continued.

County.	Total land in farms.	Land in crops.	Pasture land.			All other farm land.	Percentage of total farm land devoted to—		Acres in pasture per 100 acres in crops.
			Total.	Improved.	Woodland.		Crops.	Pasture.	
Goliad.....	388,768	60,900	73,200	5,341	17,903	49,956	15.7	18.8	120.2
Gonzales.....	622,203	184,287	320,308	11,927	283,195	15,548	29.6	51.4	173.8
Gray.....	359,329	37,016	254,037	7,368	170	246,499	15.9	70.7	445.6
Grayson.....	553,527	324,806	139,889	26,691	73,106	89,032	58.6	25.3	43.1
Gregg.....	134,386	47,953	14,280	5,048	8,611	72,203	35.7	10.6	26.7
Groes.....	320,379	100,721	156,327	21,193	110,042	22,002	31.4	48.8	155.2
Guthrie.....	377,107	161,465	141,898	5,081	132,422	73,744	42.8	37.6	87.9
Hale.....	379,670	55,440	95,812	1,704	3,297	90,811	14.6	25.2	172.8
Hall.....	458,250	88,938	318,517	38,588	21,943	255,186	19.4	76.1	391.9
Hamilton.....	450,042	108,619	247,645	20,721	104,641	122,283	24.1	55.0	228.0
Hansford.....	233,559	17,071	173,560	133,017	2,492	38,051	7.3	74.3	1,016.7
Hardeman.....	310,388	80,713	120,288	15,616	26,017	78,655	26.0	38.8	149.0
Hardin.....	45,081	4,199	2,317	43,447	1,330	38,965	9.3	3.1	55.2
Harris.....	400,649	84,586	145,328	20,721	30,069	71,812	21.1	36.3	171.8
Harrison.....	438,557	137,894	95,089	21,320	67,147	6,622	31.4	21.7	69.0
Hartley.....	516,204	16,444	551,563	142,841	2,080	409,642	3.2	32.4	115.3
Haskell.....	469,661	132,071	152,284	10,762	112,703	28,819	28.1	71.3	324.1
Hays.....	350,826	77,115	249,948	3,096	217,001	29,851	22.0	84.3	1,151.6
Hemphill.....	370,179	27,111	312,221	45,216	59,376	207,629	7.3	33.8	113.4
Henderson.....	360,219	107,231	121,624	10,258	101,663	9,703	1.4	41.3	2,968.6
Hidalgo.....	656,322	9,140	271,330	60,890	140,797	69,673	63.9	23.2	36.2
Hill.....	542,789	347,091	125,716	20,337	67,727	37,652	7	94.6	13,939.5
Hockley.....	181,432	1,231	171,595	3,335	71,947	171,595	20.1	56.9	278.9
Hood.....	237,988	48,553	135,397	3,335	71,947	58,115	41.6	45.5	109.2
Hopkins.....	442,628	183,934	200,937	42,965	116,128	41,811	31.3	20.8	166.6
Houston.....	403,255	126,119	83,971	11,918	66,241	5,729	4.3	6.5	144.1
Howard.....	853,904	38,687	55,739	854	26,627	26,258	66.3	23.0	31.7
Hunt.....	308,289	107,025	14,734	14,734	73,884	18,407	4.0	77.5	1,917.3
Hutchinson.....	371,970	15,033	288,225	45	100	288,125	2.5	95.0	3,739.5
Irion.....	151,716	3,930	146,904	14,028	95,251	51,668	3.4	88.6	2,377.8
Jack.....	541,688	66,483	321,416	286,933	208,618	98,770	3.4	8.5	59.6
Jackson.....	989,567	33,996	876,342	1,202	177,338	412,071	40	98.7	93,825.2
Jasper.....	100,910	14,354	8,556	1,202	7,314	40	14.2	26.4	37.7
Jef Davis.....	899,572	946	887,586	170,233	101,910	615,443	30.4	86.9	116.0
Jefferson.....	201,874	61,280	53,221	41,866	6,144	87,340	32.5	37.7	
Johnson.....	422,202	139,621	161,999	30,311	59,337	71,751			

TEXAS—Continued.

Jones.....	494,151	169,159	195,730	5,761	178,920	11,049	120,265	34.2	39.6	115.7
Karnes.....	407,888	104,379	167,944	1,103	242,704	12,198	47,502	25.6	62.8	245.3
Kaufman.....	454,389	229,857	167,944	25,470	103,129	33,345	56,558	50.6	37.0	73.1
Kendall.....	21,633	332,819	332,819	118	289,778	92,923	15,117	6.4	89.6	1,408.3
Kent.....	553,446	11,340	360,681	38,254	265,907	56,520	181,425	2.0	65.2	3,180.6
Kerr.....	700,319	23,721	633,249	53,912	416,861	182,476	21,349	3.4	93.1	2,733.9
Kimble.....	15,834	379,392	379,392	1,979	301,552	73,861	305,158	2.3	54.2	2,396.1
King.....	417,023	6,387	354,480	200	41,050	313,239	56,147	1.5	85.0	5,550.2
Kinney.....	562,624	2,487	566,362	38,964	370,261	137,137	(a)	4		22,772.9
Knox.....	95,061	233,075	123,319	5,767	129,319	117,989	172,269	18.3	48.6	22,772.9
Lamar.....	468,676	268,661	118,141	19,801	86,315	12,025	81,574	57.3	25.2	44.0
Lamb.....	867,459	60,809	593,819	60	160	591,569	263,535	68.3	86.3	9,726.8
Lampasas.....	453,906	60,809	385,951	8,245	299,743	87,963	1,146	13.3	80.9	631.1
Lasalle.....	996,292	8,315	208,290	25,225	81,632	124,953	773,687	20.9	86.3	2,594.3
Lavaca.....	414,973	146,437	302,565	25,271	225,210	49,114	45,071	26.6	61.1	206.6
Lee.....	284,382	75,606	163,638	4,980	149,306	9,352	45,978	25.6	57.5	216.3
Leon.....	334,613	82,009	155,557	22,464	114,252	18,841	117,047	23.1	43.9	189.7
Liberty.....	103,180	16,633	34,720	19,319	12,891	2,510	51,827	16.1	33.6	208.7
Limestone.....	466,030	273,597	116,031	8,251	77,551	60,212	66,419	56.3	30.0	53.4
Lipscomb.....	423,250	34,308	344,940	76,916	1,132	206,892	44,002	8.1	81.5	1,005.4
Live Oak.....	360,525	18,204	294,561	3,808	271,357	19,396	47,760	5.0	96.4	1,618.1
Llano.....	472,330	25,024	455,354	34,701	405,991	14,692	(a)	5.5	81.7	1,756.6
Loving.....	199,519	11	189,774		189,774	189,774	9,734	1.8	95.1	1,725,218.2
Lubbock.....	277,269	4,877	228,221	1,268	42,685	189,268	44,171	1.8	82.3	4,679.5
Lynn.....	260,792	4,593	184,148	2,425	12,525	193,198	72,051	1.8	70.6	4,000.3
McCulloch.....	557,627	86,273	405,303	57,485	378,972	64,846	(a)	15.5	88.7	574.1
McLennan.....	557,354	370,305	141,863	17,885	92,863	3,423	84,986	62.0	23.7	38.3
McMullen.....	453,500	1,146	383,882	538	46,915	7,202	68,472	84.6	64.2	33,497.6
Madison.....	229,456	63,344	147,280	7,028	133,050	7,202	18,872	27.6	64.2	232.5
Marton.....	39,425	39,570	26,618	5,602	20,521	4,95	73,217	28.4	19.1	67.3
Martin.....	271,752	4,058	153,533	58,882	85,781	8,870	114,161	1.5	56.5	3,783.5
Mason.....	583,807	36,574	573,699	14,063	390,525	173,111	(a)	6.3	99.3	1,585.0
Matagorda.....	265,343	69,401	105,263	47,951	35,242	22,100	90,649	26.2	39.7	52,874.0
Maverick.....	194,981	350	185,059	204	184,503	190,352	9,572	2.2	94.9	58,508.2
Medina.....	624,832	80,160	455,504	24,110	189,037	242,357	89,228	12.8	72.9	6,632.0
Menard.....	13,981	510,591	510,591	3,434	494,478	15,679	221,512	2.6	95.1	3,415.5
Midland.....	466,367	6,965	237,890	3,381	4,980	274,529	221,512	1.5	51.0	3,415.5
Mills.....	250,404	164,581	164,581	7,709	147,810	9,062	86,473	40.9	32.8	518.2
Mitchell.....	406,705	63,597	329,591	13,563	261,917	8,111	67,183	11.3	77.1	684.1
Montague.....	576,631	64,984	444,527	50,496	364,902	24,129	72,828	34.3	32.0	151.7
Montgomery.....	531,057	182,044	276,185	39,662	183,965	82,558	94,474	23.7	20.9	88.2
Moore.....	170,006	40,447	35,685	1,963	28,929	3,193	65,223	3.3	26.8	823.8
Morris.....	93,278	3,037	25,018	535	15,998	8,485	40,513	38.7	25.2	65.1
Motley.....	112,145	43,381	28,251	8,374	17,323	2,554	189,297	2.8	84.0	3,007.2
Naegodoches.....	862,934	24,100	724,994	22,526	641,694	60,774	189,297	28.6	15.8	55.4
Naeogoches.....	340,784	97,508	53,979	21,542	28,142	3,295	189,297	28.6	15.8	55.4
Navarro.....	561,515	327,228	165,718	29,461	88,400	47,857	75,667	58.3	29.5	50.6
Newton.....	101,693	14,718	11,218	313	10,300	605	75,667	11.0	11.0	76.2
Nolan.....	385,578	64,782	237,871	34,866	47,107	155,898	82,925	16.8	61.7	367.2
Nueces.....	1,713,184	30,578	1,141,135	20,786	380,199	740,150	541,476	1.8	66.6	3,731.9

^a See table of counties reporting an excessive acreage in pasture, on page 13.

TABLE II.—*Pasture land on farms in the United States, by counties (1910 census)*—Continued.

County.	Total land in farms.	Land in crops.	Pasture land.				All other farm land.	Percentage of total farm land devoted to—		Acres in pasture per 100 acres in crops.
			Total.	Improved.	Woodland.	Other.		Crops.	Pasture.	
TEXAS—Continued.										
Ochiltree.....	225,779	33,413	165,940	2,220	2,658	161,062	26,426	14.8	73.5	496.6
Oldham.....	513,855	5,233	230,305	.....	7,340	212,965	258,297	1.0	48.7	4,765.0
Orange.....	57,775	13,962	11,013	4,879	2,658	3,476	32,800	24.2	19.1	78.9
Palo Pinto.....	472,842	46,687	341,006	5,616	319,732	15,658	85,149	9.9	72.1	730.4
Panola.....	312,821	103,152	32,089	7,228	23,873	988	177,580	33.0	10.3	31.1
Parker.....	510,753	157,683	232,526	11,810	173,299	67,417	100,544	30.9	49.4	160.1
Parmer.....	116,083	14,459	32,000	28,488	90	3,512	69,534	12.5	27.6	221.9
Pecos.....	2,106,445	5	624,960	.....	6,600	623,360	1,536,480	.....	29.1	12,599,200.0
Polk.....	195,807	31,334	42,154	1,372	40,086	696	122,319	16.0	21.5	134.5
Potter.....	516,502	12,626	297,983	11,382	85,538	201,063	205,893	2.4	57.7	2,361.9
Presidio.....	988,288	1,710	988,053	161,778	18,780	777,495	8,525	2.1	98.9	56,026.5
Rains.....	103,581	40,129	28,052	7,023	19,474	1,555	35,350	38.8	27.1	69.9
Randall.....	278,484	42,560	181,698	67,004	61	114,633	54,226	15.3	65.2	426.9
Regan.....	443,715	1,394	105,126	680	104,446	.....	337,195	.3	23.7	7,541.3
Red River.....	407,724	164,284	71,377	20,077	46,501	4,799	172,063	40.3	17.5	43.4
Reeves.....	563,033	2,821	162,030	56	153,364	8,610	398,182	.5	28.8	5,743.7
Refugio.....	234,884	6,745	225,991	78,590	146,194	1,207	2,148	2.9	96.2	3,350.5
Roberts.....	537,377	10,500	618,212	19,319	95,545	503,348	(a)	1.9	.....	5,887.7
Robertson.....	337,775	99,611	9,596	3,058	82,338	8,907	84,297	48.6	27.8	57.3
Rockwall.....	84,317	62,424	9,506	3,058	4,836	1,702	12,297	74.0	11.4	15.4
Rooks.....	574,566	179,134	20,433	46,059	97,194	87,180	164,999	31.2	40.1	128.6
Russell.....	431,626	140,667	88,619	27,077	55,719	5,823	222,340	31.1	19.6	63.0
Sabine.....	105,529	23,245	9,078	3,199	5,405	474	73,206	22.0	8.6	39.1
San Augustine.....	137,768	12,332	3,821	3,821	8,106	405	87,662	27.4	9.0	32.6
San Jacinto.....	116,976	27,042	5,672	608	5,008	56	84,262	23.1	4.8	21.0
San Patricio.....	304,893	20,240	164,019	645	159,774	3,000	125,634	6.5	52.9	810.4
San Saba.....	636,371	62,721	542,658	1,492	469,418	71,748	50,992	9.6	82.7	865.2
Schleicher.....	822,314	10,612	780,832	13,820	604,648	162,364	30,870	1.3	95.0	7,358.0
Seelye.....	519,399	99,473	131,734	37,023	263,169	154,316	(a)	19.2	.....	1,680.5
Shackelford.....	487,375	25,702	431,918	37,023	298,716	96,179	29,755	5.3	88.6	42.1
Shelby.....	302,629	94,200	39,639	8,597	28,623	2,419	168,750	31.1	13.1	917.5
Sherman.....	255,364	20,286	186,124	134,743	408	50,972	48,954	7.9	72.9	53.8
Smith.....	447,178	181,068	97,392	18,911	73,111	5,370	168,718	40.5	21.8	.....

Somervell.....	93,616	24,649	49,034	1,220	43,857	3,957	19,933	26.3	52.4	198.9
Starr.....	675,184	18,492	71,272	735	70,367	170	585,420	2.7	10.6	385.4
Stephens.....	463,364	43,120	351,006	13,534	291,416	46,056	60,238	9.3	75.8	814.0
Sterling.....	335,321	5,570	307,640	34,501	307,500		22,111	1.7	91.7	5,523.2
Stonewall.....	400,397	34,501	265,176	39,737	139,731	85,708	100,720	8.6	66.2	708.6
Sutton.....	786,327	2,024	706,565	110	706,455		17,738	3	97.5	37,873.8
Swisher.....	298,117	43,805	158,466	215	140	158,111	96,346	14.5	53.2	365.9
Tarrant.....	467,411	144,478	213,372	61,950	84,495	66,927	109,561	30.9	45.6	147.7
Taylor.....	468,377	148,844	249,509	141,130	91,068	70,024	31.8	53.2	167.6	
Terrill.....	621,310	60	12,360	1,311	4,680	7,675	608,890	2.0	20,000.0	
Terry.....	385,737	12,829	45,526			45,526	327,372	3.3	11.8	354.6
Throckmorton.....	461,985	32,595	395,493	1,576	371,601	22,316	33,897	7.1	85.6	1,213.4
Titus.....	205,919	73,205	69,356	14,377	48,211	6,768	61,358	36.5	33.7	92.2
Tom Green.....	940,989	64,020	587,075	79,637	468,719	38,719	289,844	6.8	62.4	917.0
Travis.....	503,276	202,081	215,979	7,087	187,088	21,804	85,216	40.2	42.9	106.9
Trinity.....	120,572	20,400	22,006	1,555	20,258	193	69,166	24.4	18.3	74.9
Tyler.....	125,126	20,157	27,641	1,713	22,529	3,399	77,328	16.1	22.1	137.1
Upshur.....	250,153	86,944	27,495	7,988	19,294	213	135,714	34.8	11.0	31.6
Upton.....	800,212	483	3,210	30		3,180	796,519	1	4	664.6
Uvalde.....	656,789	25,333	348,738	16,884	289,396	42,458	282,718	3.9	53.1	1,376.6
Valverde.....	1,337,711	3,608	407,729	330	212,825	194,554	926,374	3	30.5	11,300.7
Van Zandt.....	431,394	161,196	169,476	25,795	133,400	10,272	100,722	37.4	39.3	
Victoria.....	442,977	65,703	656,532	366,083	71,851	218,598	(a)	14.8		999.2
Walker.....	182,651	53,519	28,150	3,756	24,098	296	100,982	29.3	13.4	52.6
Waller.....	193,027	65,644	76,350	35,370	26,432	14,548	51,033	34.0	39.6	116.3
Ward.....	325,108	8,044	119,032	28	60,461	58,543	198,032	2.5	36.6	1,479.8
Washington.....	344,282	136,441	132,616	26,574	77,234	48,808	55,225	39.6	44.3	1,118.5
Webb.....	1,058,274	5,355	1,027,720	89,934	811,607	126,179	25,199	5	97.1	19,191.8
Wharton.....	355,075	149,388	141,104	33,596	38,908	68,600	64,583	42.1	39.7	94.5
Wheeler.....	458,080	67,341	453,728	230,614	1,725	221,389	(a)	14.7	99.0	673.8
Wichita.....	326,628	118,029	113,694	36,546	11,583	65,565	94,905	36.1	34.8	96.3
Wilbarger.....	158,047	178,582	29,147	29,147	100,744	48,691	75,307	38.4	43.4	113.0
Williamson.....	661,646	301,925	255,521	25,900	199,762	39,859	134,200	45.6	34.1	74.7
Wilson.....	401,297	100,588	219,699	2,528	209,369	7,802	81,010	25.1	54.7	218.4
Winkler.....	363,452	202,233	344,336	6,400	1,440	336,496	18,883	39.4	94.7	147,783.7
Wise.....	489,121	192,898	292,832	29,488	146,515	56,829	63,391	35.8	21.3	59.5
Wood.....	274,476	98,148	58,377	8,764	48,333	1,220	117,951	39.4	49.6	120.7
Yoakum.....	439,779	5,383	437,832	4,350	8,320	425,162	(a)	1.2	99.6	8,133.6
Young.....	458,775	84,229	164,513	24,151	103,394	260	74,403	18.4	35.9	195.3
Zapata.....	81,347	2,343	2,083	2,083		98	50,056	5.7	2.9	50.9
Zavalla.....	443,912	1,654	392,202	2,418	389,686			4	88.4	23,712.3
Total.....	112,435,067	18,665,867	63,523,701	7,427,840	30,698,745	25,397,116	30,245,499	16.6	56.5	340.2

a See table of counties reporting an excessive acreage in pasture, on page 13.

TABLE II.—*Pasture land on farms in the United States, by counties (1910 census)*—Continued.

County.	Total land in farms.	Land in crops.	Pasture land.				All other farm land.	Percentage of total farm land de- voted to—		Acres in pasture per 100 acres in crops.
			Total.	Improved.	Woodland.	Other.		Crops.	Pasture.	
UTAH.										
Beaver.....	45,986	11,900	3,638	1,221	549	1,868	30,448	25.9	7.9	30.6
Boxelder.....	343,185	89,889	142,990	13,823	5,037	124,120	110,206	26.2	41.7	158.9
Cache.....	294,160	108,819	82,905	14,871	8,662	59,472	102,436	37.0	28.2	76.2
Carbon.....	56,653	6,906	10,847	1,252	4,492	5,103	38,840	12.3	19.1	155.7
Davis.....	127,257	37,499	37,210	1,355	2,174	33,681	52,548	29.5	29.2	99.2
Emery.....	96,708	21,674	20,111	5,470	1,672	13,069	54,923	22.4	20.8	92.8
Garfield.....	59,973	10,680	31,306	2,997	3,691	24,618	17,987	17.8	52.2	293.1
Grand.....	62,089	4,420	30,592	333	16,040	14,219	27,077	7.1	49.3	692.1
Iron.....	88,027	9,620	605	.....	370	235	77,802	10.9	7	6.3
Juab.....	108,564	22,182	32,144	19,580	7,201	5,363	54,288	20.4	29.6	144.9
Kane.....	24,773	2,869	11,755	610	8,491	2,654	10,149	11.6	47.5	409.7
Millard.....	166,627	27,308	51,970	16,421	2,850	32,719	87,149	16.5	31.2	188.9
Morgan.....	95,648	9,307	60,534	438	3,156	56,940	25,607	9.9	63.3	636.7
Piute.....	25,869	10,231	6,642	3,656	2,889	2,697	8,996	39.5	25.7	64.9
Ritch.....	149,509	31,106	86,030	38,956	118	46,956	32,373	20.8	57.5	276.6
Salt Lake.....	169,262	50,331	71,600	55,364	2,655	13,581	47,131	29.8	42.3	141.7
San Juan.....	48,797	4,400	8,132	1,140	3,642	3,050	36,265	9.0	16.7	184.8
Sanpete.....	261,771	63,936	129,723	16,200	16,150	98,373	68,112	24.4	49.6	202.9
Sevier.....	122,332	37,042	44,999	7,478	16,678	20,843	40,291	30.3	36.8	121.5
Summit.....	261,056	24,127	208,728	26,002	55,893	126,833	28,231	9.2	79.9	865.0
Tooele.....	88,332	18,246	53,521	6,080	22,544	22,097	16,565	20.7	60.6	293.3
Utah.....	82,072	23,157	24,008	5,391	3,451	15,166	34,907	28.2	29.3	103.7
Uinta.....	234,717	81,357	63,510	11,498	5,231	46,781	89,860	34.7	27.1	78.1
Wasatch.....	154,083	27,124	47,236	3,826	34,675	8,735	79,723	17.6	30.7	174.2
Washington.....	50,273	8,513	17,953	3,826	95	17,283	23,807	16.9	35.7	210.9
Wayne.....	31,617	8,142	6,850	390	2,301	4,159	16,625	23.8	21.7	84.1
Weber.....	148,359	39,741	79,837	17,008	25,554	37,575	28,781	26.8	53.8	200.9
Total.....	3,337,639	791,286	1,365,376	271,945	255,541	838,190	1,241,037	23.3	40.2	172.5

VERMONT.

Addison.....	440, 621	142, 642	173, 066	53, 476	63, 019	56, 571	124, 913	32, 4	39, 3	121, 3
Bemington.....	260, 820	61, 894	97, 675	21, 675	42, 106	33, 894	101, 253	23, 7	37, 4	157, 8
Caledonia.....	373, 946	85, 570	181, 689	31, 319	78, 430	71, 940	106, 587	23, 9	48, 6	212, 3
Chittenden.....	297, 576	95, 474	139, 461	33, 710	52, 887	32, 864	62, 641	32, 1	46, 9	146, 1
Essex.....	143, 791	29, 954	60, 213	7, 749	29, 954	22, 530	53, 624	20, 8	41, 9	201, 0
Franklin.....	361, 777	121, 930	184, 365	29, 178	63, 100	92, 087	53, 482	33, 7	38, 4	151, 2
Grand Isle.....	49, 775	24, 027	19, 121	9, 533	6, 054	3, 534	6, 027	48, 3	35, 4	79, 6
Lamoille.....	213, 218	53, 042	113, 045	20, 954	65, 055	27, 036	47, 131	24, 9	53, 0	213, 1
Orange.....	405, 134	105, 069	245, 805	26, 832	90, 953	128, 019	54, 260	25, 9	60, 7	233, 9
Rutland.....	377, 309	101, 491	191, 895	40, 688	64, 936	86, 271	83, 923	26, 9	50, 9	186, 1
St. Albans.....	424, 549	125, 880	222, 043	36, 734	91, 442	93, 867	94, 026	28, 4	50, 2	176, 4
Washington.....	389, 409	85, 998	176, 759	27, 965	57, 454	91, 340	106, 885	23, 3	47, 8	205, 5
Windham.....	538, 012	127, 368	187, 082	13, 982	118, 722	51, 378	118, 583	21, 5	48, 0	223, 4
Windsor.....			281, 942	22, 533	127, 268	132, 111	128, 702	23, 7	52, 4	221, 4
Total.....	4, 663, 577	1, 244, 071	2, 274, 161	376, 328	951, 391	946, 442	1, 145, 345	26, 7	48, 8	182, 8

VIRGINIA.

Acomac.....	185, 538	68, 472	15, 527	3, 014	3, 090	9, 423	101, 539	36, 9	8, 4	22, 7
Abernarle.....	380, 491	80, 743	140, 367	91, 715	36, 700	11, 352	165, 381	20, 9	36, 3	173, 9
Alexandria.....	41, 096	1, 555	a 1, 822	a 373	a 764	a 83	58, 719	38, 0	44, 3	117, 2
Alleghany.....	104, 006	14, 891	30, 765	7, 066	11, 074	12, 625	58, 550	14, 3	29, 6	206, 6
Amelia.....	180, 042	26, 146	32, 155	3, 768	26, 842	1, 515	130, 741	13, 8	17, 0	123, 0
Amherst.....	258, 373	47, 372	73, 320	13, 141	50, 904	9, 275	137, 081	18, 3	28, 4	154, 8
Appomattox.....	174, 341	28, 132	16, 985	3, 451	10, 964	2, 570	129, 224	16, 1	9, 7	60, 4
Augusta.....	391, 742	161, 954	91, 860	69, 430	11, 973	10, 457	137, 928	41, 3	23, 4	56, 7
Bath.....	135, 149	17, 373	29, 681	6, 297	10, 694	12, 090	88, 095	12, 9	22, 0	170, 8
Bedford.....	426, 711	92, 873	104, 273	33, 727	51, 067	19, 479	229, 565	21, 8	24, 4	112, 3
Bland.....	137, 076	20, 515	34, 307	26, 854	4, 481	2, 972	82, 254	15, 0	25, 0	167, 2
Boetourt.....	198, 903	49, 089	45, 256	26, 532	15, 999	2, 725	104, 558	24, 7	22, 8	92, 2
Brunswick.....	282, 020	47, 350	59, 746	12, 681	39, 741	7, 294	161, 843	16, 8	21, 2	126, 1
Buchanan.....	198, 379	22, 508	14, 025	11, 245	865	1, 915	174, 954	11, 3	7, 1	62, 3
Buckingham.....	283, 315	42, 804	41, 251	8, 548	26, 290	6, 413	199, 760	15, 1	14, 5	96, 4
Campbell.....	274, 739	56, 980	48, 541	14, 048	23, 937	5, 556	168, 218	20, 7	18, 0	86, 9
Caroline.....	308, 289	60, 730	49, 842	12, 237	32, 017	5, 395	197, 727	19, 7	16, 2	82, 1
Charles City.....	281, 394	65, 639	89, 063	77, 781	7, 409	3, 873	126, 892	23, 3	31, 6	135, 7
Charles.....	80, 549	17, 896	5, 541	2, 037	3, 432	72	57, 112	22, 2	6, 9	31, 0
Charlotte.....	261, 221	45, 508	33, 176	5, 478	22, 039	5, 999	182, 537	17, 4	12, 7	72, 9
Chesterfield.....	184, 732	31, 625	29, 449	4, 419	22, 321	2, 709	123, 658	17, 1	15, 9	93, 1
Clarke.....	106, 140	45, 745	39, 254	30, 743	6, 016	2, 525	25, 141	43, 1	37, 0	85, 8
Craig.....	89, 325	14, 173	20, 291	18, 479	1, 266	546	55, 061	15, 8	22, 7	143, 2
Culpeper.....	217, 937	59, 088	83, 112	68, 781	11, 501	2, 830	75, 737	27, 1	38, 1	140, 7

a Estimated.

TABLE II.—Pasture land on farms in the United States, by counties (1910 census)—Continued.

County.	Total land in farms.	Land in crops.	Pasture land.				All other farm land.	Percentage of total farm land devoted to—		Acres in pasture per 100 acres in crops.
			Total.	Improved.	Woodland.	Other.		Crops.	Pasture.	
VIRGINIA—Continued.										
Cumberland.....	162,424	31,695	34,986	6,494	25,306	3,186	95,743	19.5	21.5	110.4
Dickenson.....	130,499	19,293	16,193	11,716	4,188	289	93,013	14.8	12.4	83.9
Dinwiddie.....	264,573	52,659	34,648	6,616	27,039	1,473	177,266	19.9	13.1	65.8
Elizabeth City.....	18,915	7,307	3,219	1,680	744	795	8,389	38.6	17.0	44.1
Essex.....	144,809	30,266	30,682	9,732	17,462	3,488	83,651	20.9	21.2	101.4
Fairfax.....	190,995	54,608	45,445	24,331	19,057	2,057	90,942	28.6	23.8	83.2
Fauquier.....	382,082	95,371	137,480	114,331	13,118	10,631	149,231	25.0	9.8	39.3
Floyd.....	237,128	56,545	89,411	79,479	7,055	2,877	91,172	23.8	37.7	158.1
Fluvanna.....	151,554	25,536	33,894	8,457	22,938	2,499	92,124	16.8	22.4	132.7
Franklin.....	411,622	87,318	88,352	24,293	47,457	16,002	235,852	21.2	21.5	101.2
Frederick.....	240,127	89,508	57,994	39,690	13,620	1,681	92,625	37.3	21.2	64.8
Giles.....	146,429	25,822	33,224	7,406	7,406	3,784	76,193	17.6	30.3	172.0
Gloucester.....	113,733	32,159	5,043	3,043	4,144	2,645	69,742	28.3	10.4	36.8
Goosland.....	143,164	27,346	26,117	4,733	18,056	89,701	89,701	19.1	18.2	75.5
Grayson.....	258,813	54,767	60,677	84,683	3,321	3,673	113,369	21.2	35.0	165.6
Greene.....	87,525	21,487	37,108	21,874	11,413	3,821	28,930	24.5	42.4	172.7
Greensville.....	128,797	30,760	38,956	5,383	32,724	849	59,081	23.9	30.2	126.6
Halifax.....	498,473	104,513	69,738	18,847	42,001	8,890	324,222	21.0	14.0	66.7
Hanover.....	241,636	55,445	36,066	6,176	28,119	2,371	149,525	22.9	15.2	66.1
Henrico.....	110,723	28,575	16,706	6,248	8,913	1,545	65,442	25.8	15.1	48.5
Henry.....	219,627	40,810	26,202	8,084	13,463	4,655	152,615	18.6	11.9	64.2
Highland.....	199,393	19,254	61,882	19,055	19,820	22,007	118,257	9.7	31.0	321.5
Isle of Wight.....	153,990	40,561	19,640	1,128	15,807	2,705	93,789	26.3	12.8	48.4
James City.....	55,439	10,284	3,468	911	2,079	478	41,087	18.5	6.3	33.7
King and Queen.....	154,302	28,855	28,112	4,783	13,625	9,704	97,355	18.7	18.2	97.4
King George.....	104,424	28,462	30,611	15,427	13,199	1,985	45,351	27.3	29.3	107.6
King William.....	133,240	27,744	20,481	5,993	12,999	1,489	85,015	20.8	15.4	73.8
Lancaster.....	55,880	15,163	5,286	2,406	2,019	861	35,431	27.1	9.5	34.9
Lee.....	71,354	58,476	71,512	59,324	6,312	5,876	111,366	24.2	29.6	122.3
Loudoun.....	309,734	101,576	134,176	117,358	11,055	5,703	73,900	32.8	43.3	131.9
Louisiana.....	235,370	44,209	53,064	17,882	31,556	3,626	138,037	18.8	22.5	119.9
Lunenburg.....	210,334	36,365	29,132	5,089	22,629	1,434	144,617	17.4	13.9	79.7
Madison.....	170,805	42,016	58,233	49,441	8,384	408	70,616	34.1	34.1	138.6
Mathews.....	43,205	14,697	1,920	453	1,038	26	20,588	34.0	4.4	13.1
Mecklenburg.....	362,622	66,716	42,985	5,781	33,899	3,305	252,921	18.4	11.9	64.4
Middlesex.....	79,397	19,831	5,926	1,443	4,044	439	44,640	28.2	8.4	29.9

	210, 823	42, 801	\$8, 298	59, 120	25, 290	3, 888	79, 704	20.3	41.9	206.3
Montgomery.....	179, 164	56, 197	1, 924	1, 084	1, 155	95	121, 033	31.4	1.1	3.4
Nansmond.....	240, 824	41, 652	28, 875	9, 428	18, 027	1, 420	170, 287	17.3	12.0	69.3
Nelson.....	103, 546	13, 656	7, 005	2, 366	3, 573	1, 066	84, 885	12.9	6.6	51.3
New Kent.....	119, 530	58, 204	6, 275	716	4, 512	1, 047	54, 591	48.8	5.3	10.8
Norfolk.....	85, 436	41, 950	3, 584	906	1, 201	1, 487	37, 892	50.3	4.3	8.6
Northampton.....	95, 635	26, 733	13, 788	6, 085	6, 085	1, 197	55, 114	28.0	14.4	51.6
Northumberland.....	150, 864	26, 173	39, 793	6, 515	29, 913	3, 365	84, 898	17.3	26.4	152.1
Nottoway.....	191, 042	48, 387	42, 963	30, 661	9, 745	2, 548	99, 692	25.3	22.5	88.8
Orange.....	132, 981	40, 319	38, 360	25, 275	6, 728	6, 337	54, 302	30.3	28.8	95.1
Patrick.....	271, 147	52, 109	57, 420	20, 764	26, 584	10, 072	61, 618	19.2	21.2	110.2
Pittsylvania.....	600, 812	134, 014	67, 502	13, 809	43, 374	10, 319	390, 296	22.3	11.2	50.4
Powhatan.....	132, 106	22, 706	26, 678	4, 806	20, 195	1, 677	82, 722	17.2	20.2	117.5
Prince Edward.....	180, 661	33, 274	27, 841	3, 319	21, 785	2, 737	119, 546	18.4	15.1	83.7
Prince George.....	129, 263	42, 836	7, 633	2, 060	4, 335	1, 238	78, 794	33.1	5.9	17.8
Princess Anne.....	102, 120	46, 170	3, 884	3, 000	3, 471	113	120, 177	27.1	2.3	8.4
Prince William.....	170, 231	42, 427	51, 842	33, 473	16, 150	2, 219	7, 831	41.6	50.8	122.2
Pulaski.....	141, 981	32, 553	68, 373	57, 538	5, 836	6, 079	40, 053	22.9	48.9	213.1
Rappahannock.....	150, 632	31, 368	78, 128	67, 718	7, 597	2, 843	46, 536	20.1	50.1	249.1
Richmond.....	94, 338	21, 064	7, 073	2, 356	3, 614	1, 063	66, 461	22.3	7.5	33.6
Roanoke.....	131, 005	38, 102	37, 762	14, 483	11, 902	6, 377	55, 141	29.1	28.8	94.1
Rockbridge.....	280, 069	73, 599	73, 161	13, 762	13, 762	17, 981	138, 909	25.9	25.5	98.9
Rockingham.....	303, 042	144, 949	105, 678	72, 952	18, 965	13, 761	112, 415	39.9	20.1	72.9
Russell.....	255, 924	48, 662	112, 516	52, 384	35, 285	21, 847	94, 746	19.0	44.0	231.2
Scott.....	343, 170	64, 757	93, 636	66, 583	15, 594	11, 459	184, 777	18.9	27.3	144.6
Shenandoah.....	231, 942	86, 447	58, 825	39, 799	12, 771	6, 255	86, 670	37.3	25.4	68.0
Smyth.....	218, 634	43, 213	89, 880	51, 921	29, 781	8, 178	85, 541	19.8	41.1	208.0
Southampton.....	333, 705	82, 831	11, 565	853	5, 982	4, 730	299, 309	24.8	3.5	14.0
Spotsylvania.....	187, 105	35, 613	34, 107	13, 867	17, 826	2, 414	117, 385	19.0	18.2	95.8
Stafford.....	121, 485	26, 559	33, 630	14, 071	15, 624	3, 425	61, 896	21.9	27.2	124.4
Surry.....	115, 178	30, 093	6, 378	1, 062	3, 730	1, 566	78, 707	26.1	5.5	21.2
Sussex.....	202, 493	50, 017	16, 352	2, 164	13, 300	1, 028	135, 924	24.7	8.2	33.1
Tazewell.....	270, 581	43, 336	121, 880	69, 534	28, 251	24, 002	105, 365	16.0	45.0	281.2
Warren.....	110, 150	32, 277	35, 733	25, 480	7, 118	3, 135	42, 140	29.3	32.4	110.3
Warwick.....	21, 947	5, 861	6, 052	2, 844	4, 436	772	10, 034	26.7	27.6	110.3
Washington.....	314, 726	82, 227	105, 159	72, 131	22, 714	10, 314	127, 340	26.1	33.4	127.9
Westmoreland.....	118, 535	29, 882	15, 700	9, 612	3, 020	3, 068	72, 933	25.2	13.2	52.5
Wise.....	122, 874	23, 002	25, 886	17, 408	6, 553	1, 925	73, 986	18.7	21.1	112.5
Wythe.....	257, 207	54, 008	100, 116	83, 356	11, 786	4, 974	103, 083	21.0	38.9	185.4
York.....	50, 591	15, 454	7, 331	2, 071	4, 282	978	27, 806	30.5	14.5	47.4
CITY.										
Alexandria.....	16	7	6	.....	6	.....	9	43.8	8.7	10.3
Bristol.....	69	58	83	38	45	.....	55	65.9	20.8	31.6
Buena Vista.....	399	263	.....	.....	.....	.....	2	50.0	.....	.....
Charlottesville.....	4	2	.....	.....	.....	.....	(a)	43	9.2	22.2
Clifton Forge.....	.....	23	.....	.....	.....	.....	194	15.3	76.8	580.0
Danville.....	87	36	8	5	3	.....	.....	41.4	9.2	22.2
Fredericksburg.....	151	116	116	17	99	.....	.....	13.2	76.8	580.0
Lynchburg.....	275	42	39	22	17	.....	.....	14.2	14.2	92.9
Newport News.....	16	16	16	10	.....	6	.....	100.0	100.0	.....

a See table of counties reporting an excessive acreage in pasture, on page 13.

TABLE II.—*Pasture land on farms in the United States, by counties (1910 census)*—Continued.

County.	Total land in farms.	Land in crops.	Pasture land.				All other farm land.	Percentage of total farm land de- voted to—		Acres in pasture per 100 acres in crops.
			Total.	Improved.	Woodland.	Other.		Crops.	Pasture.	
VIRGINIA—Continued.										
CITY—continued.										
Norfolk.....	139	102	6					37	73.4	4.6
Petersburg.....	324	131				6		187	40.4	1.9
Portsmouth.....										
Radford.....	1,527	746	414	264	150			367	48.9	27.1
Richmond.....	79	31	1	1				47	39.2	1.3
Roanoke.....	31	5	2	2				24	16.1	6.5
Staunton.....	619	190	100	100				329	30.7	16.2
Williamsburg.....	535	218	104	56	48			213	40.7	19.4
Winchester.....	1,921	709	562	407	128		27	650	36.9	29.3
Total.....	19,495,636	4,514,027	4,428,410	2,385,360	1,544,914		498,136	10,553,199	23.2	22.7

WASHINGTON.

Adams.....	979,455	371,687	203,214	4,251	180	198,783	37.9	20.7	54.6
Asotin.....	180,987	40,024	104,914	1,308	21,253	82,353	21.1	55.2	262.1
Benton.....	260,044	96,475	27,035	1,737	14,467	24,831	37.1	10.4	28.0
Chelan.....	84,347	13,006	30,908	3,811	14,994	11,733	37.1	38.2	234.6
Chelan.....	152,613	41,438	59,631	4,686	32,837	22,088	37.1	38.6	142.0
Clallam.....	62,248	10,194	14,928	3,213	6,469	5,246	16.4	23.0	146.3
Clarke.....	186,929	43,538	84,066	4,842	33,738	42,486	23.3	43.4	186.2
Columbia.....	314,557	97,711	84,333	8,595	11,351	64,387	31.1	26.8	86.3
Cowlitz.....	106,553	15,359	59,932	4,995	35,910	19,027	14.4	56.2	90.2
Douglas.....	711,831	249,514	178,792	27,478	3,817	147,497	23.1	25.1	71.6
Ferry.....	101,050	13,033	41,312	6,945	24,707	9,660	12.9	40.9	317.0
Franklin.....	387,832	129,082	79,091	12,140	66,469	179,649	33.3	20.4	61.3
Garfield.....	314,609	91,606	159,411	5,624	7,959	63,592	29.1	50.6	174.0
Grant.....	647,999	216,634	100,539	31,418	68,311	330,826	33.4	15.5	46.4
Island.....	38,976	8,397	10,181	1,393	7,135	20,398	21.5	26.1	121.2
Jefferson.....	31,518	2,988	13,418	2,090	10,300	15,112	9.5	42.6	449.1
King.....	148,417	30,737	54,919	13,011	26,830	62,701	20.8	37.0	178.3

Kittap.....	42,332	5,664	10,722	649	5,391	4,682	25,946	13.4	25.3	189.3
Kittas.....	262,605	60,489	101,522	4,194	23,219	72,079	100,594	17.0	38.7	167.8
Khektat.....	330,251	91,916	188,368	15,739	35,612	137,017	248,007	17.7	35.5	200.6
Lewis.....	214,872	41,364	66,553	5,187	34,666	26,700	106,955	19.2	31.0	160.9
Lincoln.....	1,209,910	468,294	340,897	13,991	78,600	248,306	400,719	38.7	28.2	72.8
Mason.....	42,928	4,837	17,699	1,471	11,031	5,197	20,392	11.3	41.2	365.9
Okanogan.....	379,766	71,900	136,697	16,118	31,846	88,733	171,169	18.9	36.0	190.1
Pacific.....	47,092	4,981	23,559	4,608	11,936	7,015	18,552	10.6	50.0	473.0
Pierce.....	156,590	24,616	57,856	9,064	25,214	23,578	74,118	15.7	36.9	235.0
San Juan.....	66,612	8,876	29,104	1,390	19,937	7,777	28,632	13.3	43.7	327.9
Seagit.....	118,118	42,478	42,176	8,402	26,290	7,475	33,464	36.0	35.7	90.3
Skamania.....	25,631	3,221	13,535	605	3,520	9,320	8,875	12.6	52.8	420.2
Snohomish.....	118,328	20,566	39,795	5,807	17,591	16,364	57,967	17.4	33.6	193.4
Spokane.....	682,330	231,795	296,446	40,242	172,984	53,220	181,089	34.0	39.0	114.9
Stevens.....	521,239	74,906	137,454	6,662	97,018	33,774	308,809	14.4	26.4	183.5
Thurston.....	151,233	20,587	67,979	4,916	31,666	31,367	62,677	13.6	44.9	330.2
Wahkikum.....	29,030	1,951	12,568	1,068	5,254	6,246	14,511	6.7	43.3	644.2
Walla Walla.....	739,699	257,450	155,221	43,872	35,702	75,687	327,028	34.8	21.0	60.3
Whatecom.....	145,747	35,114	48,312	4,627	28,165	15,520	62,321	24.1	33.1	137.6
Whitman.....	1,187,966	525,219	218,368	52,599	16,021	149,748	446,379	44.0	18.4	41.7
Yakima.....	320,921	137,278	95,809	10,700	12,427	72,682	87,834	42.8	29.9	69.8
Total.....	11,712,235	3,604,995	3,373,864	390,098	965,331	2,018,435	4,733,376	30.8	28.8	98.6

WEST VIRGINIA.

Barbour.	200,610	43,034	105,259	77,154	14,043	14,062	52,317	21.5	52.5	244.6
Berkeley.	159,216	69,234	35,661	21,593	8,052	6,016	54,321	43.5	22.4	51.5
Boone.	88,800	15,093	5,793	4,235	832	726	67,974	17.0	6.5	38.4
Braxton.	265,181	51,242	83,655	76,084	4,100	3,471	130,284	19.3	31.5	163.3
Brooke.	52,463	17,591	13,026	6,813	3,387	2,826	21,846	33.5	24.8	74.1
Cabell.	149,512	37,999	36,560	22,786	9,389	4,375	74,963	23.4	24.4	96.2
Calhoun.	149,037	31,845	43,969	28,349	4,372	11,238	73,223	21.4	29.5	188.1
Clay.	83,083	17,305	12,876	8,480	3,285	1,111	52,912	20.8	15.5	74.4
Doddrige.	197,932	34,203	110,700	75,441	17,069	18,250	53,029	17.3	55.9	333.7
Fayette.	110,142	27,362	25,103	14,703	7,842	2,558	57,677	24.9	22.8	91.8
Glmer.	193,669	33,849	82,856	64,578	8,505	9,773	76,964	17.5	42.8	244.8
Grant.	208,119	26,083	71,252	37,014	15,045	19,193	110,784	12.5	34.2	273.2
Greenbrier.	330,489	59,822	105,963	54,098	30,988	20,877	164,704	18.1	32.1	177.1
Hampshire.	347,171	57,560	83,320	44,232	27,140	11,948	206,291	16.6	24.0	144.8
Hancock.	46,292	15,717	14,628	4,463	4,187	978	15,947	34.0	31.6	93.1
Hardy.	248,869	34,459	47,475	22,805	20,417	4,253	166,935	13.8	19.1	137.8
Harrison.	247,835	42,908	169,002	127,731	16,937	24,334	35,925	17.3	68.2	393.9
Jackson.	284,746	69,368	125,316	89,164	18,584	17,598	90,062	24.4	44.0	180.6
Jefferson.	120,786	66,206	35,096	27,463	6,683	19,850	19,484	54.8	29.1	53.0
Kanawha.	252,402	62,409	73,040	45,814	17,069	11,617	114,963	24.7	29.7	120.2
Lewis.	243,153	37,906	147,532	92,505	14,846	40,715	57,715	15.6	60.7	389.2
Lincoln.	191,862	44,899	32,994	20,300	7,845	4,849	113,969	23.4	17.2	73.5

TABLE II.—*Pasture land on farms in the United States, by counties (1910 census)*—Continued.

County.	Total land in farms.	Land in crops.	Pasture land.				All other farm land.	Percentage of total farm land devoted to—		Acres in pasture per 100 acres in crops.
			Total.	Improved.	Woodland.	Other.		Crops.	Pasture.	
WEST VIRGINIA—Continued.										
Logan.....	90,421	13,528	5,555	3,164	1,919	472	80,338	13.6	5.6	41.1
McDowell.....	128,784	11,517	5,477	1,976	2,069	892	111,790	8.9	4.3	243.7
Marion.....	173,529	39,527	96,344	78,238	11,887	6,219	37,058	22.8	55.5	47.5
Marshall.....	189,727	60,549	71,367	52,486	10,369	8,512	57,811	31.9	37.6	117.9
Mason.....	254,210	62,528	101,350	63,701	25,864	11,725	90,332	24.6	39.9	162.1
Mercer.....	185,108	36,027	57,484	35,863	14,138	7,483	91,597	19.5	31.1	159.5
Mineral.....	136,995	26,335	41,143	19,241	19,701	2,201	89,447	16.8	26.2	156.2
Mingo.....	93,637	13,175	15,797	1,722	9,550	13,225	64,665	14.1	16.9	119.9
Monongalia.....	187,822	41,543	107,752	88,422	9,970	9,360	38,527	22.1	57.4	259.4
Monroe.....	241,342	45,606	100,104	39,524	22,730	17,910	95,572	18.9	41.5	217.7
Morgan.....	107,659	24,942	25,641	11,015	12,012	2,614	57,076	23.2	23.8	102.8
Nicholas.....	157,375	32,519	44,188	33,064	9,291	1,833	80,668	20.7	28.1	135.9
Ohio.....	59,508	25,598	23,918	12,237	5,463	6,219	9,992	43.0	40.2	93.4
Pendleton.....	312,694	33,655	84,708	23,393	30,757	30,440	194,331	10.8	27.1	251.7
Pleasants.....	73,556	17,732	29,304	19,909	4,482	4,913	26,520	24.1	39.8	165.3
Pocahontas.....	293,871	30,322	74,922	20,497	31,537	22,888	128,027	13.0	32.0	247.1
Preston.....	265,289	67,822	96,212	61,498	23,580	11,134	131,255	23.0	32.6	141.9
Putnam.....	185,747	46,173	53,309	34,210	13,985	5,114	86,265	24.9	28.7	115.5
Raleigh.....	139,134	29,663	33,102	23,568	7,788	1,776	76,369	21.3	23.8	111.6
Randolph.....	289,080	39,887	113,418	39,069	59,928	13,821	135,775	13.8	39.2	284.3
Ritchie.....	240,968	43,114	123,344	89,582	14,738	19,024	74,500	17.9	51.2	6.1
Roane.....	297,582	60,692	128,601	102,235	9,756	16,610	98,289	21.1	44.7	211.9
Summers.....	192,420	36,317	53,051	27,957	17,976	7,138	103,052	18.9	27.6	146.1
Taylor.....	97,745	20,816	61,294	52,400	5,076	3,818	15,635	21.3	62.7	294.4
Tucker.....	93,314	15,404	21,191	10,886	6,378	3,927	56,719	16.5	22.7	137.6
Tyler.....	157,028	34,101	72,205	57,271	5,923	9,311	50,726	21.7	46.0	211.7
Upshur.....	193,028	36,065	79,143	53,461	4,873	20,809	77,820	18.7	41.0	219.5
Wayne.....	240,753	52,972	71,459	48,497	19,408	3,554	116,322	22.0	29.7	134.9
Webster.....	109,043	17,718	17,439	8,834	8,036	569	73,886	16.3	16.0	98.4
Wetzel.....	190,497	49,906	62,243	48,675	5,282	5,280	78,348	26.2	32.7	124.7
Wirt.....	124,134	28,068	44,038	31,001	7,894	3,143	52,028	22.0	35.5	156.9
Wood.....	205,466	54,519	90,567	61,488	19,971	9,108	60,350	26.5	44.1	166.0
Wyoming.....	138,613	22,184	15,264	6,377	6,498	2,389	121,165	14.0	9.6	68.8
Total.....	10,026,442	2,066,648	3,484,060	2,252,876	714,584	516,600	4,475,734	20.6	34.8	168.6

^a Estimated.

TABLE II.—*Pasture land on farms in the United States, by counties (1910 census)*—Continued.

County.	Total land in farms.	Land in crops.	Pasture land.			All other farm land.	Percentage of total farm land devoted to—		Acres in pasture per 100 acres in crops.	
			Total.	Improved.	Woodland.		Other.	Crops.		Pasture.
WISCONSIN—Continued.										
Polk.....	378,057	120,077	196,875	12,792	136,151	61,105	31.8	52.1	164.0	
Portage.....	411,217	157,864	139,081	25,309	89,679	114,302	38.4	33.8	88.1	
Price.....	119,005	16,422	39,417	2,054	22,271	63,166	13.8	33.1	240.0	
Racine.....	199,412	114,778	58,128	17,173	23,196	26,506	57.6	29.1	50.6	
Richland.....	362,080	122,358	175,237	46,303	99,491	64,485	33.8	48.4	143.2	
Rock.....	439,441	255,854	125,547	59,287	33,623	58,040	58.2	28.6	49.1	
Rusk.....	113,638	16,404	38,497	3,181	18,562	58,737	14.4	33.9	234.7	
St. Croix.....	417,892	232,930	134,791	33,723	76,368	50,171	55.7	32.3	89.0	
Sauk.....	503,174	204,098	181,569	33,394	111,061	117,507	40.6	36.1	57.9	
Sawyer.....	43,049	6,750	6,854	416	4,550	24,445	15.7	15.9	101.5	
Shawano.....	330,926	118,699	124,157	22,701	67,016	138,070	31.2	32.6	104.6	
Sheboygan.....	306,216	153,130	93,754	48,507	21,005	59,352	50.0	30.6	61.2	
Taylor.....	136,451	27,138	59,425	2,197	36,646	49,888	19.9	43.6	219.0	
Trempealeau.....	451,101	189,952	153,197	39,280	86,411	107,952	42.1	34.0	80.6	
Vernon.....	487,746	174,775	a 269,523	a 49,598	a 186,859	43,448	35.8	55.3	154.2	
Vilas.....	19,269	2,694	4,115	335	1,227	12,400	14.0	21.4	152.7	
Walworth.....	336,776	181,108	a 124,037	a 38,050	a 51,261	28,631	54.6	36.8	67.4	
Washington.....	145,370	25,465	48,817	1,792	29,323	71,148	17.5	33.6	192.2	
Washington.....	262,902	137,213	90,986	15,438	41,823	33,725	34,703	52.2	34.6	
Waukesha.....	324,832	176,891	106,495	24,571	46,577	35,047	53.6	32.3	60.2	
Waupaca.....	417,309	154,633	113,691	25,645	72,886	119,085	37.1	34.4	92.9	
Waushara.....	366,102	146,414	118,721	30,812	75,911	100,967	40.0	32.4	81.1	
Winnebago.....	210,598	143,806	71,414	23,836	20,873	45,378	55.2	27.4	49.7	
Wood.....	283,782	78,796	124,503	6,817	66,037	80,483	27.8	43.9	138.0	
Total.....	21,000,066	8,617,542	7,775,002	1,699,127	4,171,617	4,666,922	40.9	36.9	90.2	

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BULLETIN No. 627

Contribution from Office of Farm Management
W. J. SPILLMAN, Chief



Washington, D. C.



February 13, 1918

COST OF HARVESTING WHEAT BY DIFFERENT METHODS.

By ARNOLD P. YERKES, *Assistant Agriculturist*, and L. M. CHURCH, *Assistant in Farm Accounting*.

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DEVELOPMENT OF WHEAT-HARVESTING METHODS.

Within the memory of men now living, the entire wheat crop of this country was cut with cradles, bound by hand, and thrashed with flails, crude thrashing machines, or tramped out by animals drawing spiked rollers. The cost of harvesting and thrashing wheat by such means was naturally high, usually consuming one-fifth of the value of the crop.¹ But the time required to do the work when such methods were used was even more important than the expense involved, as it increased the danger of loss from storms to a great extent, and demanded a large number of hands to harvest even a limited acreage within the season available. It was necessary to start cutting at the earliest possible moment, selecting those parts of the field where the grain ripened first, in order to insure completing the harvest before heavy losses occurred from shattering the over-ripe grain. Two acres was considered a fair day's work for a man in cradling wheat, and another hand would be kept busy binding and shocking the wheat cut by one cradler. It is obvious that the acreage of wheat that could be raised per farm under such conditions was very limited because of the large amount of hand-labor involved.

¹ Tenth Census of the U. S. (1880), Vol. III, p. 529.

UNITED STATES DEPARTMENT OF AGRICULTURE



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At the time these crude methods were used, wages for both man- and horse-labor were much lower than at present. To-day, with the unprecedented high wages for hired help for farm work, and its corresponding scarcity, together with the increased cost of maintaining horses, the necessity for using the most improved methods and machinery in order to reduce the amount of man-labor to a minimum is obvious.

During the last century there has been remarkable progress in the development of harvesting equipment. The mower, the reaper, the header, the binder, and the combined harvester have followed each other in rapid succession, substituting at first horse-labor for man-labor, and later introducing mechanical power in the form of steam and internal-combustion engines for horse-labor.

The cost of harvesting wheat at the present time varies widely in different sections of the country largely because of the different methods employed in these operations. In most cases the particular manner in which the crop is handled is influenced by climatic conditions and the requirements of the cropping system followed, as well as by the character of the wheat itself. The various methods followed throughout the country, therefore, generally are those which have been found to be well adapted to the particular conditions existing where they are used, although local custom has in some places operated to continue systems that are more expensive than others which would be entirely practicable.

The purpose of this bulletin is to point out, so far as possible, the comparative cost of the different methods employed in harvesting wheat and to outline the points which must be considered in calculating this cost in such a way that farmers readily may insert the figures which apply to their particular conditions, and thus be able to compare their present costs with those of others. By so doing, those who are not now doing the work in the most economical manner may be led to consider the adoption of some other practicable system which will result in a saving of time and money.

A careful study of the cost of harvesting wheat has shown that the greater items of expense are for man- and horse-labor and depreciation of machine, and in endeavoring to cut down harvesting expenses the farmer should give careful attention to the most important items. The large machines show the smallest cost per acre, and, other things being equal, the farmer therefore should use the largest machine practicable under his conditions in order to reduce the man- and horse-labor required. If he can make his machines last longer by a little inexpensive care, such as better housing, more careful overhauling during the winter months, etc., it may result in material savings in total harvesting expense. In the following pages are shown some figures which, though they may not be directly

applicable to many particular cases, should be of considerable value to farmers who are interested in cutting down their harvesting expenses, by showing them where the greatest expenses commonly are incurred.

THE BINDER.

By far the largest percentage of the wheat crop of the country is to-day harvested with the binder, the use of this machine being almost universal. Although headers are used in large numbers and over a wide area through the Middle West and West, binders also are used throughout the same area, it being quite common to find both machines on one farm. In some seasons only the binder will be used, in others only the header, while often both will be used, depending upon conditions which will be referred to later. The only wheat-growing sections where the binder is not used on the greater part of the crop are in the States of Washington, Oregon, and California, and parts of Idaho, Utah, Wyoming, and Montana, where much of the wheat is cut and thrashed with combined harvesters (see pp. 18 to 22), although even where these outfits are commonly used binders also are employed to some extent. (See Pl. I, fig. 1.)

The cost of harvesting may be somewhat greater where the binder is used than where the work is done with headers or combined harvesters. The binder, however, has a distinct advantage over these machines in that the work of harvesting may be begun from one to two weeks earlier with the binder than with either the header or combine, since wheat can be cut with a binder while in the early dough stage and placed in shocks to complete ripening; at the same time it is comparatively safe from destruction by storms. This feature is a very valuable one in many cases, not only for the reason just given but also because it permits the work of harvesting to be extended over a much longer period than with the other machines mentioned, thus requiring fewer horses and men to harvest a given acreage.

DUTY.

The cost of harvesting wheat with a binder varies considerably, being influenced by the several factors mentioned below. Data have been collected showing the daily duty of six-, seven-, and eight-foot binders, and the results of the tabulation of these data are shown in Table I. By this it will be seen that the six-foot binder is most commonly drawn by three horses, while on the seven-foot cut four horses are generally used. On the eight-foot binder, the use of four horses is practically universal. On the six-foot binder, the extra horse appears to make but a little over an acre's difference in the quantity of work done per day. The six-foot binder apparently does not overload three horses except where the yield is exceptionally heavy, or

where hilly or soft ground is encountered, and three horses, therefore, under most conditions, do a fair day's work for a machine of this size. The extra horse on a seven-foot binder adds slightly over $2\frac{1}{2}$ acres per day to the work accomplished, which would seem to indicate that three horses are somewhat overloaded with such a machine.

TABLE I.—Average acres cut by 6-, 7-, and 8-foot binders in a 10-hour day. (235 reports.)

Width of cut and number of horses.	Acres cut.		
	Per binder.	Per horse.	Per foot of cutter bar.
6-foot, 3 horses.....	10.90	3.63	1.82
6-foot, 4 horses.....	12.10	3.03	2.02
7-foot, 3 horses.....	12.50	4.17	1.79
7-foot, 4 horses.....	15.10	3.78	2.16
8-foot, 4 horses.....	17.00	4.25	2.13

The larger binders are more efficient in the use of both horse- and man-labor than the smaller sizes. For example, on the six-foot binder each horse cuts approximately 3.6 acres per day, whereas on the eight-foot binder each horse cuts practically 4.25 acres per day, or accomplishes 17 per cent more work. This is probably accounted for by the fact that the weight of the eight-foot binder is only slightly more than that of the six-foot. Each horse on the six-foot binder drawn by three horses has to move more weight than on the eight-foot binder drawn by four horses, while the amount of work on the cutter-bar and other mechanism is in almost exactly the same proportion. It is not surprising, therefore, that more ground will be covered per horse by the larger binders, since the draft per horse will be less.

In considering the amount of work done per horse on the different sizes of binders, the last column of Table I, showing the amount of grain per foot of cut, must be studied. Most binders when in use do not cut the full width of the cutter-bar a great part of the time, as it is difficult to drive so as to take a full swath at all times without occasionally missing some grain, and most drivers, therefore, will err on the safe side by allowing a few inches of the cutter-bar to travel over stubble. This margin will be practically the same for a six-foot cutter bar as for the eight-foot, but the percentage of the sickle which is idle will of course be greater for the six-foot than for the eight-foot size.

From these facts, it is apparent that the cost of cutting wheat with a binder will vary with the size of the outfit used, the cost being lowest with the eight-foot cut. In the past many farmers have been prejudiced against the large binders because of the heavy side draft on the horses, but this objection no longer holds, as with most modern

binders it has been overcome entirely. In most cases where there is a considerable acreage to be cut and the necessary horses are available the purchase of the large binder will prove to be the most profitable because of the greater efficiency in the use of both man- and horse-labor.

Other factors which influence the amount of work done per day, and therefore the cost, are yield per acre, especially of the straw, the character of the soil, whether soft or firm, rough or smooth, and the topography of the farm, whether level or hilly. The working ability of the horses used also has considerable bearing on the acreage covered. The condition of the working parts of the machine, particularly the sickle, will likewise affect the amount of work done per day.

The figures here given are intended to approximate the average conditions so far as possible. In order to make them comparable, an arbitrary value for both man- and horse-labor has been used in all cases in calculating the cost of doing the work by the various methods, although these values will vary in different parts of the country. For the same reason the data collected have been adjusted to a uniform day of 10 hours; that is, if a man reported 18 acres as an average day's work with an eight-foot binder, working 12 hours per day, in tabulating the data his figure would be changed to 15 acres per day of 10 hours, since his rate of cutting was $1\frac{1}{2}$ acres per hour. In applying the figures to any particular farm, therefore, the prevailing cost of man- and horse-labor, as well as length of day, should be substituted.

Assuming man-labor to be worth \$2 per day, including board (which is probably not far from the actual cost on a large percentage of farms during harvest, although temporary help may cost considerably more), and horse-labor 12 cents per hour, or \$1.20 per day (a figure which it is believed will represent a fair average for the country as a whole, being slightly above the cost for parts of the Middle West and West, but lower than most of the Eastern States), the approximate cost of cutting wheat with the different sized binders is shown in Table II. No figures have been given for the five-foot binder, as this size is no longer in common use.

As would naturally be expected, the eight-foot binder drawn by four horses is more economical than the six- or seven-foot binder drawn by either three or four horses, as the cost for both man- and horse-labor is lower. The highest cost per acre for man-labor is of course found where the six-foot binder and three horses are used. In this case the cost of the man-labor per acre in cutting wheat is 18 cents, or 50 per cent more than where the eight-foot binder is used. The difference in the horse-labor per acre between the six-foot

machine drawn by three horses and the eight-foot outfit with four horses is 5 cents per acre, or about 18 per cent. Where the seven-foot binder with three horses is used the cost per acre for horse-labor is only 1 cent greater than where the eight-foot binder and four horses are used. In other words, horse-labor is utilized almost as economically on a seven-foot binder drawn by three horses as on an eight-foot outfit drawn by four horses, but the cost of man-labor is greater on the smaller machine. The charge per acre with the seven-foot binder is exactly the same with either three or four horses when the values of man- and horse-labor bear the relation which they do in this table, as the cost for horse-labor is less where only three horses are used, while that for man-labor is correspondingly lower where four horses are used. This point is well worth considering where hired help is scarce and extra horses are available.

TABLE II.—*Labor cost of cutting one acre of wheat with binders of different sizes and with varying numbers of horses, man-labor at \$2 per day, and horse-labor at \$1.20 per day of 10 hours (based on figures in Table I).*

Width of cut and number of horses.	Cost per acre.		
	Total labor.	Man-labor.	Horse-labor.
6-foot, 3 horses.....	\$0.51	\$0.18	\$0.33
6-foot, 4 horses.....	.57	.17	.40
7-foot, 3 horses.....	.45	.16	.29
7-foot, 4 horses.....	.45	.13	.32
8-foot, 4 horses.....	.40	.12	.28

In actual practice it often is possible to hire horses from neighbors as low as 75 cents each per day and board, many farmers being willing to hire their horses out at a very low figure in addition to their board, when they have no work for them. The cost of horse-labor per hour therefore is frequently less with a hired horse under these conditions than where the horse is owned and maintained during the entire year.

INTEREST AND DEPRECIATION.

In this bulletin the interest charges on the various machines have been computed in all cases at 6 per cent on one-half the cost of such equipment, which figure represents the average investment. Many men fail to consider interest charges at all, whereas others allow interest on the first cost of their equipment for each year of its life. This is incorrect, as the value of the equipment decreases each year of its life, and if charges are made against it for depreciation it is obvious that interest should not be charged against these amounts during subsequent seasons. Assuming that the equipment is worthless at the end of its life (that is, ignoring its junk value), the average amount invested will be 50 per cent of its first cost, and the

method here used of charging interest at 6 per cent on one-half of the first cost for each year distributes the interest charges equally over its entire life, since it would be unfair to charge the first season's use with interest on the full value and the last season's use with interest only on the remaining value.

It is difficult to arrive at any satisfactory figures for depreciation charges on binders, as the life of these machines varies within wide limits; the acreage they cover per year also varies, and the care they receive, both in and out of use, has considerable effect on their years of service. The small binders are found most commonly in the Eastern States, where the acreage covered annually (including all crops on which they are used) is comparatively small.

In Table III are shown some figures on the cost for interest and depreciation on binders, based on approximate figures for the cost, life, and acres covered annually. All three of these items vary in different sections. The acres cut annually by a binder do not seem to have a very direct influence upon its life except where the acreage is extremely large. There is a certain deterioration due to age which appears to limit the length of life in years whether the binder does a fair amount of work each season or not.

TABLE III.—*Approximate cost, life in years and acres, and annual interest and depreciation charges on binders.*

Type of binder.	Approximate cost. ¹	Acres covered annually (all grain). ¹	Life in—		Average annual cost per acre.		
			Years. ¹	Acres. ¹	Interest at 6 per cent on average investment.	Depreciation.	Total.
6-foot.....	\$125	50	15	750	\$0.07½	\$0.16½	\$0.24
7-foot.....	135	100	11	1,100	.04	.12	.16
8-foot.....	145	150	10	1,500	.03	.09½	.12½

¹ Approximate figures based on tabulation of 235 reports. There is a variation in the cost of binders in different States, depending largely upon the freight rates. The acres cut annually, and life in years, also vary widely in different sections and with different care.

REPAIRS.

The amount of repairs required by a binder depends to a great extent upon the care it receives. If kept well oiled and otherwise in proper condition, the repairs, except for the replacement of the canvas, should be practically negligible. Occasional breaks will occur, but most of the parts liable to breakage can be replaced at slight expense. Many farmers have reported the use of a binder for several years without a cent being spent for repairs, whereas in other cases repairs have ranged from \$10 to \$15 annually. As a rule the most expensive item of repairs, as stated above, is the canvas. The number of acres which can be cut with one canvas varies considerably,

being influenced by the number of acres cut annually, and the care given it when idle. Where a binder covers a large acreage each year the acres cut with one canvas may be twice as great as with a binder used on only a small number of acres each year, as it deteriorates whether used or not. If properly protected when idle, a binder canvas should cut from 400 to 800 acres and perhaps in some cases 1,000 acres.

In western New York (see United States Department of Agriculture Bulletin 338) it was found that it cost nearly 60 cents per day of use to keep a grain binder in repair, or 0.058 cent per acre cut, and that before a binder is worn out 25 per cent of its first cost, on an average, must be spent to keep it in running order.

The percentage of the first cost represented by repairs is usually less for small binders than for the larger sizes, because of the much smaller amount of work ordinarily done by them during their years of service, while their first cost is only slightly less than for the larger sizes. It is believed that 20 per cent of the first cost for six-foot binders, 25 per cent for seven-foot, and 30 per cent for eight-foot machines will approximate the average repairs required for these outfits. Repair charges for six-, seven-, and eight-foot binders figured on this basis are shown in Table IV.

In the eighth column of Table V the approximate cost of binder twine per acre will be found. This varies, of course, with the yield of straw. The twine required in the West is usually about $2\frac{1}{2}$ pounds per acre, while in the East the average is nearer 3 pounds. The cost per pound is generally slightly higher in the West than in the East, but it has been figured in all cases on the basis of 3 pounds per acre, and as costing 11 cents per pound, which is a little higher than the average price in the East during the season of 1916 but slightly less than the retail price to the western farmer during the same season.

From the figures given in Tables I to IV, inclusive (to which the twine cost must be added, as well as cost for shelter, if any), it is an easy matter to calculate the comparative cost of cutting an acre of wheat with a six-, seven-, or eight-foot binder. The figures from the tables mentioned (excepting the shelter cost) have accordingly been summarized in Table V and show that the cost of cutting an acre of wheat ranges from 88.4 cents where an eight-foot binder is used to \$1.173 for a six-foot binder, each machine being drawn by four horses. In other words, the expense of cutting an acre of wheat with the smaller outfit is nearly 33 per cent greater than where the larger binder is used. The figure in which the farmer is most interested, however, is the cost per bushel, which is readily found by dividing the cost per acre by the average yield. In the last column in Table V are given the costs per bushel for the different sized outfits, based on a yield of 16 bushels per acre, which is about the average yield for the country as a whole. This shows approximately 7

cents per bushel for the six-foot, 6 cents for the seven-foot, and 5½ cents for the eight-foot binder. Where the yield is above the average the cost per bushel will, of course, be reduced.

TABLE IV.—*Repair costs on binders.*¹

Type of binder.	Total repairs during life.	Per cent of first cost spent for repairs during life.	Cost of repairs per acre cut.
6-foot.....	\$25.00	20	\$0.033
7-foot.....	33.75	25	.03
8-foot.....	43.50	30	.029

¹ Calculations based on prices given in Table III.

The cost for shelter has been omitted in all cases because this item varies so greatly and in many cases is insignificant, since a great many binders, particularly in the West, have no shelter whatever except for the canvases and sickles, which usually are taken off and stored in a dry place during the winter. In the East binders are sheltered almost universally when not in use, ordinarily in barns or other buildings which are used primarily for other purposes, and a legitimate charge against a binder for shelter under these conditions is practically negligible. On the other hand, where a binder is sheltered in a substantial implement shed the annual cost for interest, depreciation, taxes, and repairs may amount to from \$3 to \$5, or even more, as it occupies considerable floor space and does not permit of other implements being stored on top of it.

TABLE V.—*Cost of cutting 1 acre of wheat with binder, calculated from data shown in Tables I to IV, inclusive.*

Width of cut and number of horses.	Cost of cutting 1 acre of wheat.							Cost per bushel for 16-bushel yield.
	Total.	Man labor.	Horse labor.	Inter-est.	Depre-ciation.	Repairs.	Twine. ¹	
6-foot, 3 horses.....	\$1.113	\$0.18	\$0.33	\$0.07½	\$0.16½	\$0.033	\$0.33	\$0.0695
6-foot, 4 horses.....	1.173	.17	.40	.07½	.16½	.033	.33	.0733
7-foot, 3 horses.....	.97	.16	.29	.04	.12	.03	.33	.0606
7-foot, 4 horses.....	.97	.13	.32	.04	.12	.03	.33	.0606
8-foot, 4 horses.....	.884	.12	.28	.03	.09½	.029	.33	.0552

¹ Based on 3 pounds per acre, and costing 11 cents per pound (see text).

AUXILIARY BINDER ENGINES.

A factor in reducing the cost of harvesting with a binder under certain conditions is a small gasoline engine attached to the binder and furnishing power to operate the mechanism, which is ordinarily driven by power from the horses through the medium of the bull wheel. The use of these binder engines, as they are called, has increased considerably during the last two or three seasons, particu-

larly in certain sections where wet ground has made the operation of the binder difficult.

The use of these engines not only lessens the draft for the horses (usually to a sufficient extent to permit of the binder being pulled by one or two horses fewer than the number commonly used), but also permits cutting heavy grain at slower speeds for the outfit as a whole than would be possible without such an auxiliary source of power (since the sickle runs at a constant speed at all times), and allows the grain to be harvested with a binder on ground where the bull wheel would slip if it were required to transmit power to the cutting and binding mechanism.

These engines cost about \$150, but their use is by no means confined to the binder alone, as most owners who have them use them for numerous other odd jobs about the farm where belt power can be utilized. Under these conditions their estimated average life is about $9\frac{1}{2}$ years. In some instances the engines are used practically every day of the year for pumping water, except while on the binder. Under such conditions the overhead charges of depreciation, interest, and repairs, which would be chargeable against harvesting, amount to a very small figure, while the operating expenses will be only about three-fourths of the daily labor cost of one horse, and the engine will in nearly every case decrease the number of horses required by at least one.

The owners of these outfits report that from 2 to 5 gallons of gasoline are required to operate the engine per day, the average being a fraction less than 4 gallons, while about 1 pint of lubricating oil per day appears to be a fair average. With gasoline at 20 cents per gallon, and lubricating oil at 40 cents, this would make the daily operating expense amount to about 85 cents. The overhead charges will vary according to the amount of other work done by the engine annually.

The engine not only decreases the number of horses required, but in most cases will effect a considerable increase in the acres cut per day. Reports from farmers who have used these outfits indicate that an increase of from 4 to 5 acres per day may be expected in the area covered with the binder under the conditions existing where they were being used, which were for the most part unfavorable conditions such as those previously mentioned.

The repairs on the outfits concerning which the reports were received had averaged slightly less than \$3 annually, although the average age was only $3\frac{1}{2}$ years. The repairs during the latter years of the engines' lives would in all probability be somewhat higher than this figure.

The possibility of effecting a saving in the cost of harvesting wheat under many unfavorable conditions by means of the binder engine

seems great enough to warrant careful consideration of these outfits on the part of many wheat growers who would have use for such an engine in other ways.

SHOCKING.

The practice of shocking wheat after being cut with a binder is almost universal. It is occasionally possible to thrash wheat immediately after being cut with a binder, the bundles being loaded directly on to the wagons from the piles left by the binder, but this is not common, partly because the wheat may not be fit to thrash and partly because a thrashing outfit is not available when needed.

Hauling bundles to the stack without shocking is also practiced to some extent, and where this can be done a saving of about 1 cent per bushel is effected: but in the majority of cases the wheat is placed in some kind of shocks before being stacked or thrashed.

The cost of shocking wheat varies with the yield, condition of the bundles, size of machine used in cutting, and the amount of carrying done by the binder. The character of the shocks also will have some effect, although it takes practically as long to build a poor shock as a good one.

The average acres shocked per day by one man, tabulated according to yield per acre, are shown in Table VI. It will be seen that the acres shocked per day in the two groups having yields of over 20 bushels are disproportionately less than in the two groups with yields of 20 bushels or under. This seeming irregularity is accounted for by the fact that a large percentage of the reports on low yields come from sections having a large acreage and light straw. The average cost of about 1 cent per bushel as shown in Table VI is, therefore, approximately correct. On account of the relatively small cost of shocking compared with the protection it affords, many men shock their wheat even if it is to remain in the field but a very short time.

TABLE VI.—*Acres shocked per day per man and cost per acre and per bushel in relation to yield per acre. (Based on labor at \$2 per day, 264 reports.)*

Yield per acre.	Average yield per acre.	Acres shocked per day per man.	Cost per acre.	Cost per bushel.
Under 20 bushels	15	12½	\$0.16	\$0.01
20 bushels1.....	20	12½	.16½	.008
21 to 30 bushels.....	26.2	8½	.23	.009
31 bushels and over.....	37.4	7½	.26½	.007

¹ A number of men reported their yield as 20 bushels per acre, and it was deemed advisable to leave these estimates in one group.

COMPARISON OF COSTS—OLD METHODS VS. NEW.

It is very interesting to compare the costs of cutting wheat as it is usually done to-day with the methods in use 75 years ago. It is very generally believed that modern methods always result in greatly

reducing the cost of an operation, but from the cost figures given below it will be seen that the principal effect of improved harvesting machinery has been to increase to a very large extent the amount of work which one man can accomplish in a day with the assistance of horse-labor and machines over what was formerly done by man-labor alone.

For example, the average cost of cutting with a binder, as shown in Table V, is \$1.022 per acre, and the average cost of shocking, as shown in Table VI, is 20.5 cents, or a total of \$1.23 for the two operations. In the Transactions of the New York State Agricultural Society, volume 10 (1850); page 550, the cost of cradling and binding (and the shocking was probably done at the same time) is given as 70 cents per acre on a 20-bushel yield. In the Report of the Department of Agriculture for 1853, page 143, the cost of cradling, binding, and shocking an acre of wheat, where the yield was also about 20 bushels, is given as 75 cents per acre.

In other words, the cost of cutting, binding, and shocking wheat to-day, with an average yield of 16 bushels per acre, would be slightly less than 8 cents per bushel, whereas in the cases just mentioned it was a little under 4 cents per bushel. The average farm price per bushel for wheat during the 10 years 1906-1915 was about 87 cents (see United States Department of Agriculture Yearbook for 1915), so it will be seen that the cost of harvesting in recent years has represented about one-eleventh of the selling price of the crop, whereas when hand methods were used the cost of harvesting represented less than one-thirtieth of the selling price. The cost of harvesting to-day, therefore, represents a greater percentage of the selling price of the crop than it did when the old hand methods were used. However, to-day two men (one shocking), with three or four horses, will cut, bind, and shock about eight times as much wheat as two men cutting with a cradle and binding by hand. It should be borne in mind, of course, that the price for labor at the time cradles were used was considerably less than at present. To make a direct comparison of the cost of the two methods the same price for labor should be used in both cases. If man labor was worth \$2 per day (the figure which has been used in the computations herein), the cost per acre by the hand methods would be approximately \$1.60 as against \$1.23 with the binder, where the yield was 16 bushels per acre.

It is also interesting to compare the amount of work done per day per horse with that accomplished by one man using the old hand methods. By Table I it will be seen that the acres cut per horse in one day varied from about 3 to 4½ acres. To cradle, bind, and shock 1 acre per day where the yield was about 20 bushels was a fair or average day's work for one man; a good, experienced hand

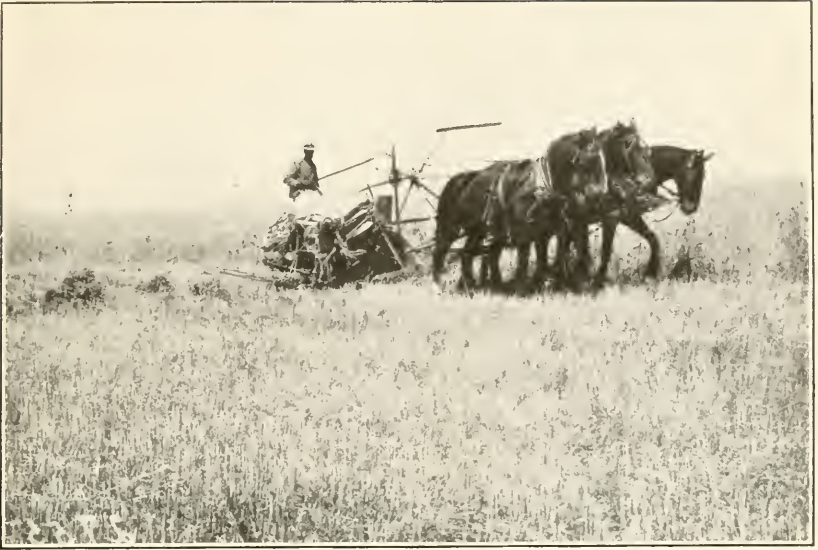


FIG. 1.—BINDER IN OPERATION.



FIG. 2.—HORSE-DRAWN HEADER IN OPERATION.



FIG. 1.—HORSE-DRAWN COMBINE IN OPERATION.

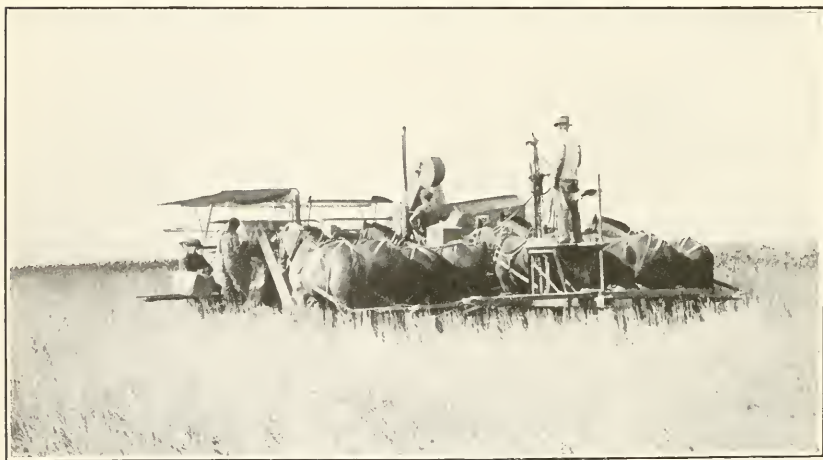


FIG. 2.—THE SMALL COMBINE; A TYPE THAT HAS ATTAINED GREAT POPULARITY IN RECENT YEARS.

could, however, do considerably more. It would seem, therefore, that the work done by a horse in one day is not much more than three times the amount performed by a man, although the working power of a horse usually is considered to be ten times greater than that of a man (Kent). This is accounted for probably by the fact that the horse's strength is less directly applied to the work than is that of the man, there being greater losses through friction and a much greater amount of weight to be moved. From the figures shown in Tables I to VII, inclusive, it will be seen that the cost of cutting, shocking, and stacking wheat ranges from about 11 to 15 cents per bushel.

STACKING.

The acreage covered per day by a given crew in stacking wheat depends upon the yield, distance hauled, size of loads, and method used. For example, two men and four horses, with either one or two of the bundle wagons which are commonly found in the wheat-growing sections of the Northwest, where both men pitch and no one is required on the load, will be able to stack more wheat, other things being equal, than will two men following the usual practice in the East of one pitching while the other man loads. The wagons used in the two cases are usually very different, the western "bundle wagon" being especially built for use in the manner above mentioned, whereas with the type of wagon usually found in the East it would be impossible to haul a very large load in this way, because of the difficulty of putting many bundles on such a wagon in such a way that they would carry well. Although the loads hauled on the western bundle wagons do not contain quite so many bundles as do those in the East when loaded by hand, they are put on in less time and with one-half the man-labor, which more than offsets this objection. If two bundle wagons are available each man can pitch on a load and take it to the stack, where one will pitch off while the other stacks. This combination is probably the most efficient crew which can be used in stacking wheat, provided the haul is not too long. It is especially recommended for consideration by eastern wheat growers, as in many cases it would be an easy matter to place a temporary rack on their wagons, thus making them well suited for use in the manner described. The adoption of this method would materially reduce the cost of stacking.

Six acres per day for two men and one team appears to be a fair day's work in stacking wheat under most eastern conditions, whereas in the western sections where the more efficient methods are employed 8 acres per day for two men and two horses and 10 acres per day for two men and four horses would appear to be a fair average. Based on these figures the cost of stacking per acre for man- and horse-labor would be as shown in Table VII. No allowance has

been made for the use of the wagon in any case, as this is a factor which is exceedingly hard to determine with accuracy, since the wagons are used for so many other purposes. If properly cared for they will last many years and the cost would, therefore, be practically negligible.

From the figures in this table it will be seen that the cost of stacking wheat varies from 80 cents to \$1.06½ per acre, or from 5 to 6½ cents per bushel on a 16-bushel yield. The cost of stacking is little if any greater than the cost of hauling from shock to the separator when thrashing. Having the grain in stacks expedites thrashing somewhat and at the same time reduces the number of men and horses required.

Where stacking is properly done the grain is better protected in stacks than in shocks.¹ In wet seasons or when thrashing can not be done soon after cutting, the importance of this protection is increased. A sweating process also takes place in the stack, which improves to some extent the color, condition, and test weight of the grain and its milling and baking qualities. The improvement may be sufficient to obtain a better market grade, with resulting higher price when sold. A similar sweating process apparently may take place in shock-thrashed wheat after being placed in the bin, but to take advantage of this the farmer must have storage room for his thrashed grain and must also get it thrashed from the shock while it is in as good condition as when placed in the stack.

TABLE VII.—*Labor cost per acre and per bushel of stacking wheat with man-labor at \$2 and horse-labor at \$1.20 per day of 10 hours.*

Operation.	Number of horses.	Acres covered per day.	Labor cost per acre.			Cost per bushel (16-bushel yield).
			Man.	Horse.	Total.	
1 man pitching and 1 man loading (1 wagon) ¹ ...	2	6	\$0.66½	\$0.40	\$1.06½	\$0.66½
2 men pitching (1 wagon) ²	2	8	.50	.30	.80	.05
2 men pitching (2 wagons) ²	4	10	.40	.48	.88	.05½

¹ Hayracks are commonly used in the East.

² Western type of bundle wagon.

Other advantages of stacking are that it makes it possible in wet weather to thrash the wheat more completely from the straw, thus saving more of the grain, and to remove more of the chaff, thus securing cleaner grain. Thrashing can begin sooner after rains if wheat is stacked, especially if the stacks are protected by a cover of any kind. In thrashing from the shock after a period of rainy weather the grain secured is nearly always somewhat damp and tough, as the tendency is to begin thrashing too soon after rains. Stacking also permits early fall plowing, which is particularly de-

¹ Acknowledgment is due Messrs. Clyde E. Leighty and Carleton R. Ball, agronomists in charge of Eastern and Western Wheat Investigations, respectively, for information concerning the effect of stacking on the quality of wheat.

sirable in certain sections (see Farmers Bulletin 678, "Growing Hard Spring Wheat.").

The two more important advantages of stacking, therefore, are the protection from the weather and, generally, the improved quality of the grain. These results are likely to follow *good* stacking. Where the stacking has been poorly done there is often a different story, the grain being in worse condition when thrashed from the stack than it would have been if thrashed after a reasonable time in the shock.

HEADERS.

Thousands of acres of wheat are harvested annually by means of the header, but this machine is, for the most part, an auxiliary of the binder for reasons mentioned below. Although usually there is a slight saving in harvesting with the header compared with the binder, in most sections there are some seasons when it is impracticable to run the header, so that it is very common to have binders on farms where headers are used. (See Pl. I., fig. 2.)

The principal advantages of the header, in addition to its economy under certain conditions, are that it eliminates considerable hand labor, covers more ground per day, saves the cost of twine, expedites thrashing because of the smaller amount of straw handled, and will harvest short grain that could not be cut and bound with a binder. In certain sections headers are kept largely for the last-mentioned purpose, since in areas where there is little rainfall there will often be a fair yield of wheat on straw that is altogether too short to handle with a binder. In such cases the header will remove the heads and place them in the header wagons with practically no loss. In some localities it is frequently desirable to plow the stubble immediately after harvest, and when a field has been headed there are no shocks to interfere with or delay this work.

The disadvantages of the header are several. The wheat must be allowed to ripen upon the stalk sufficiently to keep well in the stack. yet, when harvesting is not begun until the grain is in this condition, before it can be completed much of the wheat will be so ripe that considerable loss may result from shattering, especially with certain varieties. It seldom happens that all parts of a large field will ripen evenly; certain low spots where there is a surplus of moisture will remain green for several days after the grain around them is fit to cut with a header. The green heads from such spots, if harvesting is done with a header as soon as the remainder of the field is ready to cut, may cause considerable loss in the stack by reason of heating and molding.

The header requires more men and horses to operate it efficiently than are needed for two binders, five to eight men and ten to sixteen horses being employed in the crews. The same number of men and horses using binders could cut and shock a larger acreage per day

than a single header could cover, but the grain would yet have to be hauled for stacking or thrashing.

The straw remains on the field, which is undesirable in many sections where there is not sufficient moisture in the soil to cause it to decompose if turned under. This feature is also an objection on farms where it is desired to use the straw for bedding, since it requires considerable time and labor to cut and haul the straw after it has been headed.

In those sections where thrashing from the shock is the common practice, and where most of the thrashing is done by large custom outfits whose owners furnish the entire crew, the grain that has been headed, and of course stacked, ordinarily is left until all shock thrashing on the route has been completed, since thrashing from the stack does not require so many men, and no bundle teams. The owner of the rig naturally wishes to complete all the work where his entire crew will be needed before laying some of them off and beginning work that will require fewer men and horses. On the other hand, in those sections where heading is the most common practice, the stacks probably will be given preference, since the crops of the largest growers usually will be headed, and the custom thrashers naturally prefer to make sure of the largest jobs.

The sizes of headers most commonly used are 12 and 14 feet. A six-horse team is found most commonly on the twelve-foot machine, although eight horses are sometimes employed where the grain is particularly heavy or where the land is in such condition as to make a very heavy draft. On the fourteen-foot machine eight horses are used most frequently.

A fair day's work of ten hours with a twelve-foot header is about 24 acres, and with a fourteen-foot machine about 28 acres. The acreage covered in ten hours by a given size of header will not, of course, vary greatly with the different sized crews, provided the crew is sufficient to keep the header at work.

The additional men and horses required vary considerably in different sections and under different conditions—that is, according to the yield of grain, the distance the loads must be hauled to the stacks, and the character of the ground over which hauling is done. For instance, in the wheat-growing sections of Washington and Oregon the ground is hilly and the yield of wheat heavy. Here a common crew is four header wagons, each with one driver and two horses, one man loading, one man stacking, and another to help pitch off at the stack, making a total of eight men and sixteen horses, whereas in the Middle West, where the ground is level and the yield comparatively light, many headers are operated with six horses and only two header wagons, each with a driver and two horses, one loader and one man at the stack, making a total of five men and ten horses.

It is obvious that the cost of harvesting an acre of wheat with headers of the same size will vary with the number of men and horses in the crew, whereas the cost per bushel will depend largely upon the yield. The overhead charges per acre—that is, interest, depreciation, and repairs—will depend, of course, upon the number of acres harvested annually and the life of the machine. The first cost of headers is considerably higher in the Pacific Coast States than in the Middle West, owing to the difference in freight rates. The cost for wagons depends upon the extent to which they are used for other work. The header box itself generally is built especially for use in heading wheat, and the interest, depreciation, and repairs on these boxes should in such cases be charged against the wheat. They are inexpensive, however, since they usually are made on the farm from cheap lumber; \$8 per box probably would be a fair average cost. The repairs to the boxes are practically negligible, being made from odds and ends of lumber which are available. Few header boxes are painted, and yet fewer are sheltered; but since in the regions where they are used there is comparatively little rain their life is longer than might be expected, 10 years probably being a fair average figure. The running gears generally are used for other purposes during the remainder of the year. It is, therefore, impossible to arrive at any reliable figures as to what percentage of the overhead charges on a header wagon are properly chargeable against the wheat.

Based on the figures already mentioned for the crews and overhead charges, Table VIII has been prepared to show the approximate cost of harvesting an acre of wheat with twelve- and fourteen-foot headers, with two common sizes of crews for each.

TABLE VIII.—*Cost of harvesting an acre of wheat with headers of various sizes and different sizes of crews, with man-labor at \$2 and horse-labor at \$1.20 per day of 10 hours.*

Size of header and crew.	Daily cost of operating the outfit.				Cost per acre.	Cost per bushel.	
	Total.	Man-labor.	Horse-labor.	Interest, depreciation, and repairs on headers.		Based on 16-bushel yield.	Based on 30-bushel yield.
12-foot, with 5 men and 10 horses ¹	\$25.40	\$10.00	\$12.00	² \$3.40	\$1.06	\$0.07	.....
12-foot, with 6 men and 11 horses ³	32.20	12.00	16.80	² 3.40	1.34	.....	\$0.045
14-foot, with 6 men and 12 horses ⁴	29.75	12.000	14.40	⁵ 3.35	1.06	.07	.....
14-foot, with 8 men and 16 horses ⁶	38.55	16.00	19.20	⁵ 3.35	1.38	.....	.046

¹ Crew made up as follows: 1 driver and 6 horses with header; two header wagons with 2 drivers and 4 horses; 1 man loading wagon and 1 man on stack.

² Based on annual duty of 300 acres and 24 acres per day.

³ Crew made up as follows: 1 driver and 8 horses with header; 3 wagons with 3 drivers and 6 horses; 1 loader and 1 man on stack.

⁴ Crew made up as follows: 1 driver and 6 horses on header; 3 wagons with 3 drivers and 6 horses; 1 loader and 1 man on stack.

⁵ Based on annual duty of 450 acres and 28 acres per day.

⁶ Crew made up as follows: 1 driver and 8 horses on header; 4 wagons with 4 drivers and 8 horses; 1 loader and 2 men at stack.

From Table VIII it will be seen that the cost of heading and stacking an acre of wheat varies from \$1.06 to \$1.38, according to the size of the crew. The cost per bushel will, of course, depend upon the yield. In the last two columns are shown the approximate cost per bushel based on yields of 16 and 30 bushels per acre. The cost per day with the small crews has been divided by 16, and the cost per day with the large crews has been divided by 30, in order to approximate actual conditions, since the larger crews are used more often where the yields are heaviest. From these columns it will be seen that the cost per bushel ranges from $4\frac{1}{2}$ to 7 cents. The cost of cutting an acre of wheat with a header and stacking the heads is very little greater than the cost of cutting when the work is done with a binder. It will be seen, therefore, that there is generally a saving in harvesting with a header when the cost of shocking and stacking, or hauling to the separator, is considered.

COMBINES.

By far the cheapest method of harvesting and thrashing wheat practiced in this country at present is by means of the combined harvester, a machine that cuts the heads from the wheat and thrashes them at the same operation. Unfortunately the use of this outfit has been limited to certain sections where the grain ripens on the stalk. (Pl. II, fig. 1.)

"Combines," as they are commonly called in the sections where they are used, vary considerably in size and weight, according to the type and make. The early forms of combines were just what the name implies, i. e., a combination of two machines, a header and a separator, so arranged that the header delivered the cut heads directly to the thrashing cylinder. The first outfits were drawn by horses, and both the header and separator mechanisms were operated by "bull" or drive wheels. A little later steam was utilized to operate some combines, and still later gasoline engines, either in the form of tractors or mounted on the combines themselves as single units, were used. At present most combines are still drawn by horses, although auxiliary gasoline engines frequently are used to operate the mechanism, the horses merely moving the outfit.

The combine, like most other harvesting machinery, has undergone considerable improvement during the last few years, and instead of being merely a combination of two machines primarily designed for two different kinds of work, the combines of to-day are designed and built for the complete operation of cutting and thrashing the grain. The width of swath cut by combines varies from about 7 to 25 feet. The first combines were used principally on very large areas of wheat, and were of necessity of large size, in order to complete the work during the weather suitable for harvest. They required about

thirty or more horses to pull them, which added considerably to the expense, as many extra horses had to be maintained throughout the entire year so as to be available at harvest time. Of late years the smaller outfits have been increasing in number very rapidly. These small rigs are entirely practicable on small areas, since their price is lower than for the larger types, and their weight is so much less that fewer horses are required to operate them. (See Pl. II, fig. 2.) The amount of work done per day with the different sized outfits is shown in Table IX.

TABLE IX.—*Acres cut and bushels thrashed by different sized combines in a 10-hour day. (65 reports.)*

Width of combines, and horses used.	Acres per 10-hour day.			Bushels thrashed per day (30-bushel yield).	Usual number of men in crew.
	Per combine.	Per horse.	Per foot of cut.		
7 feet, 8 horses.....	12.4	1.55	1.77	372	2
9 feet, 10 horses.....	13.6	1.36	1.51	408	2
12 feet, 22 horses.....	19.9	.90	1.66	597	4 or 5
14 feet, 24 horses.....	20.6	.86	1.47	618	5
16 feet, 28 horses.....	27.0	.96	1.69	810	5
18 feet, 30 horses.....	31.0	1.03	1.72	930	5
20 feet, 30 horses.....	34.0	1.13	1.70	1,000	5 or 6
24 feet, 36 horses.....	42.0	1.17	1.75	1,260	5 or 6

NOTE.—The number of horses used on the different sizes of combines varies considerably according to the yield of wheat, the condition of the soil, the topography of the field, and the particular type or make of machine. The figures shown in the first column are about the most common teams for the sizes given; the number used in individual cases on the larger outfits are frequently from 1 to 4 above or below the figures given.

From this it will be seen that there is considerable irregularity in the number of acres cut per day by the different sized outfits, which is due probably to the small number averaged in most of the groups. The yield per acre usually makes but little difference in the acres covered per day except as mentioned below, since the machines must be kept moving at a certain speed in order to do good work. Therefore, in heavy grain, on hilly land, soft ground, etc., it is often necessary to use extra horses in order to keep the outfit moving at the required speed. If the additional horses are not available heavy pulling will cut down the amount of work done per day because of the more frequent resting of the horses that will be necessary.

In the fifth column of Table IX is shown the number of bushels thrashed per day by the outfits of different sizes based on a yield of 30 bushels, which is close to the average yield in the sections where combines are used. The seven- and nine-foot machines usually are operated by two men, one driving and regulating the height of the cutter-bar according to the height of the grain, the other bagging the thrashed wheat and sewing the sacks. The number of bushels thrashed per day per man with the outfits requiring only two men to operate them is considerably higher than with the larger machines which require four or five men, with the exception of the very

largest outfits, which show about the same efficiency as the small ones. It is also interesting to note that the number of bushels thrashed per day per man with these small combines is usually equal to and sometimes greater than the amount of grain thrashed per day with the small thrashing outfits used in the East. When to this is added the fact that two men have covered almost as great an acreage in a day with a combine, cutting, thrashing, and sacking the grain, as two men could cover with a binder, cutting, binding and shocking, the saving which is accomplished through the use of combines is readily apparent.

In order to ascertain the cost per bushel for thrashing with a combine it is, of course, necessary to consider depreciation, interest on investment, repairs, and operating expenses of these outfits. (See Tables X, XI, and XII.)

TABLE X.—Overhead expenses per year, per day, per acre, and per bushel; average cost and estimated life of, and acres cut annually by, different sized combines (65 reports).

Width of swath.	Average annual overhead expenses on combines.							Average cost.	Estimated, life in years.	Average acres cut annually, to date.
	Total. ¹	Depreciation.	Interest on investment at 6 per cent.	Repairs. ²	Total per—					
					Day. ³	Acre. ³	Bushel (30-bushel yield). ³			
<i>Feet.</i>										
7	\$172.49	\$106.49	\$33.00	\$33.00	\$9.10	\$0.734	\$0.0214	\$1,100	10.33	235
9	184.04	112.04	36.00	36.00	9.30	.684	.0228	1,200	10.71	269
12	233.36	115.41	50.55	67.40	8.95	.450	.0150	1,685	14.60	519
14	233.31	114.59	50.88	67.84	9.73	.472	.0157	1,695	14.80	494
16	209.05	87.95	51.90	69.20	6.58	.244	.0081	1,730	19.67	858
18	269.37	127.06	60.99	81.32	8.35	.269	.0090	2,033	16.00	1,000
20	310.05	146.25	70.20	93.60	7.93	.233	.0078	2,370	16.00	1,330
24	425.00	250.00	75.00	100.00	8.92	.213	.0071	2,500	10.00	2,000

¹ Exclusive of overhead charges for shelter, taxes, and insurance.
² Figured at 3 per cent of first cost for seven- and nine-foot sizes, and 4 per cent of first cost of all larger sizes. (See text.)
³ Based on figures shown in or derived from Table IX.

TABLE XI.—Labor costs per day, per acre, and per bushel for different sized combines and crews, man-labor being considered as worth \$2 and horse-labor \$1.20 per day of 10 hours (65 reports).

Width of cut and crews most commonly used with each outfit.	Labor cost per day.			Labor cost per acre. ¹			Total man- and horse-labor cost per bushel.
	Total.	Man-labor.	Horse-labor.	Total.	Man-labor.	Horse-labor.	
7 feet; 2 men, 8 horses.....	\$13.60	\$4.00	\$9.60	\$1.10	\$0.32	\$0.78	\$0.0365
9 feet; 2 men, 10 horses.....	16.00	4.00	12.00	1.18	.30	.88	.0392
12 feet; 4 men, 22 horses.....	34.40	8.00	26.40	1.73	.40	1.33	.0376
14 feet; 5 men, 24 horses.....	38.80	10.00	28.80	1.88	.48	1.40	.0628
16 feet; 5 men, 28 horses.....	43.60	10.00	33.60	1.61	.37	1.24	.0538
18 feet; 5 men, 30 horses.....	46.00	10.00	36.00	1.48	.32	1.16	.0495
20 feet; 5 men, 30 horses.....	46.00	10.00	36.00	1.35	.29	1.06	.0451
24 feet; 6 men, 36 horses.....	55.20	12.00	43.20	1.32	.29	1.03	.0438

¹ Based on acres and bushels per day as shown in Table IX.

TABLE XII. *Average labor and overhead expenses per day, per acre, and per bushel.¹*

Width of combine.	Average labor and overhead expenses.				
	Per day.			Per acre.	Per bushel.
	Labor.	Overhead.	Labor and overhead.		
<i>Feet.</i>					
7.....	\$13.60	\$9.10	\$22.70	\$1.83	\$0.061
9.....	16.00	9.30	25.30	1.86	.062
12.....	34.40	8.95	43.35	2.18	.073
14.....	38.80	9.73	48.53	2.36	.079
16.....	43.60	6.58	50.18	1.86	.062
18.....	46.00	8.35	54.35	1.75	.058
20.....	46.00	7.93	53.93	1.59	.053
24.....	55.20	8.92	64.12	1.53	.051

¹ Based on data in Tables IX, X, and XI.

Table X shows the annual overhead expenses based on the average first cost as shown in the ninth column, and annual repairs based on 3 per cent of the first cost for the seven- and nine-foot sizes and 4 per cent for the larger sizes. In this connection it may be pertinent to state that the seven- and nine-foot outfits are, for the most part, individually owned and are used only on the farm of the owner, while the larger rigs are in many cases used more or less for custom work and therefore cover a considerably greater acreage each year. The repairs on the small machines are consequently somewhat less annually, but for the acreage covered and bushels thrashed are slightly higher.

From the last column in Table XII it will be seen that the total cost of cutting and thrashing a bushel of grain with a combine varies from about 5.1 cents for the large outfits to a fraction under 8 cents for the fourteen-foot size. The expense for labor for the small outfits is lower in proportion to the amount of work done per day than for the larger ones, but the overhead charges are slightly greater for the reason that the small outfits are not used as many days annually because of the fact, as previously mentioned, that they are largely owned by individual farmers and do very little custom work. Six cents per bushel is probably a fair general average cost for cutting and thrashing wheat with a combine where the yield is in the neighborhood of 30 bushels. At this rate the cost of harvesting and thrashing wheat is between one-third and one-fourth of the cost in sections where the wheat is cut and thrashed at two separate operations with a consequent increase in man- and horse-labor.

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UNITED STATES DEPARTMENT OF AGRICULTURE
BULLETIN No. 628

Contribution from the Bureau of Animal Industry
A. D. MELVIN, Chief

Washington, D. C.



January 28, 1918

WINTERING AND FATTENING BEEF
CATTLE IN NORTH CAROLINA

By

W. F. WARD

Animal Husbandry Division, Bureau of Animal Industry

AND

R. S. CURTIS and F. T. PEDEN

Of the North Carolina Agricultural Experiment Station

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INTRODUCTION.

In the fall of 1913 the Bureau of Animal Industry, United States Department of Agriculture, in cooperation with the North Carolina Agricultural Experiment Station, began a series of extensive beef-cattle experiments on the farm of T. L. Gwyn, in Haywood County, N. C. The work was located in the western part of the State because of the wide range of adaptation, applying not only to North Carolina, but also to a number of surrounding States. The western part of North Carolina is extremely mountainous and rough, presenting a problem of peculiar importance to the farmer or cattle grower. The extremely rough character of the region makes good grazing ample when the land is properly cleared and seeded. The area available for the growing of crops for winter maintenance is restricted, however, because of the mountainous condition, and this makes the first three divisions of the experiments reported herein of unusual importance to the stock grower.

The subject discussed, comprising three years' experimental work, consists of: (a) Wintering steers in barns and on pasture preparatory to grazing on pasture either alone or in combination with cottonseed cake; (b) wintering steers on pasture preparatory to summer

grazing; (c) the summer fattening of steers on grass and cotton-seed cake; and (d) the winter fattening of beef cattle.

The significance of these problems to the stock grower under the conditions mentioned will be brought out clearly in the discussions which follow. It is strikingly illustrated in the division dealing with the wintering of steers on grass. When there is not enough feed available for wintering as many cattle as can be grazed during the summer, the farmer is losing money, for all his grass can not be utilized during the grazing season. The experiments have proved beyond a doubt that steers can be wintered most satisfactorily on specially prepared winter pastures, and at a cost from 30 to 50 per cent less than upon the common farm roughages. This indicates the importance of improved methods of handling cattle and the possibilities of the mountains for cattle raising.

The importance more particularly of the pasture work in the mountainous part of North Carolina and of surrounding States can not be overemphasized, considering the possibilities of winter and summer pasture development. The large areas of cut-over timber lands, such as those used for the winter pastures in this experimental work, would accommodate large herds of beef cattle if properly seeded. Winter pastures and corn silage for winter maintenance will solve many of the difficulties of the cattle grower. The mountainous condition of the region makes the production of stockers and feeders especially practicable because of the larger amounts of pasture that can be utilized and the minimum of winter feeds necessary for the maintenance and growth of such cattle. This may be appreciated by those not acquainted with local conditions by stating that in many of the mountain counties but 5 to 10 per cent of the land can be cultivated, and much of this is hillsides or steep land that should be in grass. The fattening of cattle is less practicable because of the greater amounts of feeds necessary. Where feeds have to be shipped in by rail, as is usually the case with the concentrates, the distance from the railroad stations makes this practice prohibitive for many farmers.

These statements in the main illustrate the conditions under which the work was carried on and why certain parts of it were so outlined and emphasized. Although much of this work will be of value to stock growers in the Piedmont or lower mountain sections, its value is more pertinent to the mountain areas of the section shown in the outline map. (See fig. 1.)

KIND OF STEERS USED.

The steers used in this work were all native cattle raised in western North Carolina. They were a good uniform lot of grade Shorthorn, Aberdeen Angus, and Hereford breeding with a little Devon blood

showing. The cattle were mostly 2-year-old steers, averaging about 800 pounds in weight in the fall. Most of them had been dehorned previous to their purchase and the remainder were dehorned before being placed in the feed lot. The cattle are charged in all tables and statements at the actual cost per hundredweight.

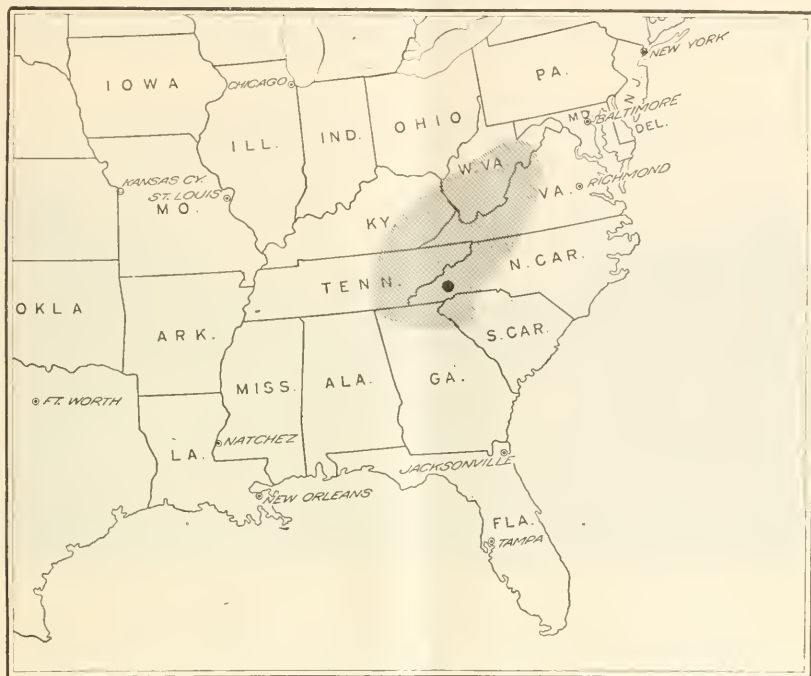


FIG. 1.—Map showing location of experimental work (heavy black dot) and area (shaded) suitable for similar cattle-feeding operations; also principal cattle markets.

CHARACTER AND PRICES OF FEED USED.

Local conditions will determine to a large extent the prices of feeds. In the financial statements for each year the feeds are figured at actual cost, but in all the comparative tables the feeds are figured at an average price for the three years, which is as follows:

Pasture.....	\$1.00 per steer per 28 days.
Cottonseed cake.....	30.00 per ton.
Corn silage.....	3.00 per ton.
Hay (alone).....	15.00 per ton.
Hay, stover, and straw mixed.....	10.00 per ton.
Hay and stover mixed.....	10.00 per ton.
Ear corn.....	0.83 per bushel.

The feeds used were all of very good quality. The cottonseed cake was cracked on the farm. The only difference between cottonseed cake and cottonseed meal is that the cake is unground. The cake is

much better than meal to feed in the open for several reasons: A sudden rain will not injure cake to such an extent that the steers will not eat it: wind will not blow it away; and it is hard enough so that the steers must chew it, thus preventing greedy ones from eating more than their share, which they could do if meal were fed. The winter pasture consisted of orchard grass, blue grass, herd's grass, and clover, which had grown up during the summer without being grazed.



FIG. 2.—Character of grazing lands and pasture.

I. WINTERING STEERS PREPARATORY TO GRAZING ON PASTURE.

OBJECT OF THE WORK.

Most of the cattle in the mountainous section of North Carolina are roughed through the winter, that is, carried on very light rations, and then finished on pasture for feeders the following summer. The experimental work was undertaken in order to determine, first, just how much it costs to carry stock cattle through the winter; second, if it is advisable to allow steers to lose in weight during the winter months; third, to determine not only the best and most economical method of wintering cattle, but also the effect the different methods of wintering cattle have on the way they gain in weight on pasture the following summer.

PLAN OF WORK.

This particular work was planned to cover a period of three years in order to get an average of season, feed, cattle, and condition tending to produce variation. The steers were divided into four lots, using a carload in each lot, and those in each corresponding lot were

fed the same ration each year. The plan was not to make the cattle in the various lots gain in weight, but rather to winter them economically, using light rations even though they lost some weight during the winter, the fattening to be done on grass the following summer. With the amounts of feed used the steers were wintered as well if not better than the average stock cattle are wintered in the mountains.

An outline of the work is given in Table 1 in order to present a clear idea of the nature of the tests conducted.

TABLE 1.—*General plan of the three years' experiments.*

Lot No.	Average number of steers per lot for the 3 years.	Winter feeding. ¹	Summer feeding. ²
1	24	Ear corn, corn stover, hay, and straw ³	One-half on grass, one-half on grass and cottonseed cake.
2	24	Corn silage, corn stover, hay, and straw ³	Do.
3	33	do. ³	Grass.
4	19	Winter-grazed, feeding during snows.....	Do.

¹ From time cattle were taken off pasture in December until turned on pasture about Apr. 15.

² From time cattle went on grass in spring to about Sept. 1.

³ Corn stover and hay were used the first winter.

The cattle in Lot 1 were fed during the winter each year on ear corn and a light ration of corn stover, hay, and straw. These cattle were divided in the spring into Division A, finished on grass alone, and Division B, fed on grass with a small ration of cottonseed cake in addition.

The cattle in Lot 2 were fed during the winter each year on corn silage, corn stover, hay, and straw. In the spring the cattle were divided and fed the same as Lot 1.

The steers in Lot 3 were wintered the same as those in Lot 2. The following summer they were all finished on grass.

The steers in Lot 4 were wintered on pasture, getting no feed or shelter except during snows, when they were brought to the barn and fed a small ration of dry roughage or dry roughage and ear corn combined. The pasture on which these cattle were grazed and finished is described on page 15.

METHOD OF FEEDING AND HANDLING THE STEERS.

The steers in Lots 1, 2, and 3 were fed about 8 a. m. and 4 p. m. The steers of Lots 2 and 3 were fed silage alone in the morning and corn stover, hay, and straw in the afternoon. The steers in Lot 1 were given one-half of the corn stover, hay, and straw in the morning and the other half in the afternoon. The ear corn was chopped and given at one feed in the morning.

The corn stover and hay were mixed together in equal quantities and run through a feed cutter before being fed. Where stover, hay, and straw were used, these feeds were mixed, one-third each, and

run through the feed cutter. The steers in Lot 4, on winter pasture, were fed only during snows, when they were brought to the barn and given a small ration of ear corn, corn stover, and hay. As soon as the snow melted they were taken back to pasture. These steers had no shelter at all, other than the natural shelter furnished by trees, thickets, coves, etc. The cattle in the barns were turned out into lots around the barn in the afternoon, and left about three hours if the weather was clear; if the weather was bad, they were left out only long enough to get water. The steers were weighed every four weeks, early in the morning, before being fed and watered.

AMOUNT OF FEED CONSUMED.

In considering the amount of feed consumed, it should be noted that these cattle were getting only maintenance rations sufficient to keep them in good, strong, thrifty condition. Table 2 shows the total amount of feed consumed and the average daily ration per steer during each of three winters.

TABLE 2.—Average daily rations (three winters).

1913-14.

Lot No.	Number of steers.	Number of days.	Ration.	Total feed per steer.	Daily feed per steer.
				Pounds. ^a	Pounds.
1	25	128	Ear corn ¹	276	2.15
			Corn stover and hay ¹	1,250	9.76
2	25	128	Corn silage ¹	2,041	15.95
			Corn stover and hay ¹	665	5.19
3	35	123	Corn silage.....	2,006	16.31
			Corn stover and hay.....	605	4.92
4	17	112	Winter pasture ²		

1914-15.

1	24	131	Ear corn ³	391	2.99
			Corn stover, hay, and straw ³	1,434	10.95
2	24	131	Corn stover, hay, and straw ⁴	789	6.03
			Corn silage ⁴	1,807	13.80
3	31	131	Corn stover, hay, and straw ¹	791	6.04
			Corn silage ⁴	1,717	13.11
4	26	131	Winter pasture ⁵		

1915-16.

1	24	119	Ear corn.....	374	3.14
			Corn stover, hay, and straw.....	1,358	11.41
2	24	119	Corn silage.....	2,142	18.00
			Corn stover, hay, and straw.....	714	6.00
3	33	119	Corn silage.....	2,142	18.00
			Corn stover, hay, and straw.....	714	6.00
4	16	119	Winter pasture ⁶		

¹ Fed 2.43 pounds cottonseed cake daily to each steer of Lots 1 and 2 during the last 16 days of experiment.

² Each steer of Lot 4 was fed an average of 5.86 pounds of hay for each of 15 days of the winter when the grass was covered with snow. This was charged in cost of wintering.

³ An average of 1.65 pounds of cottonseed meal was fed to each steer daily for the last 16 days.

⁴ Silage was not fed to the steers of Lots 2 and 3 for the last 16 days of the experiment. Stover was fed as the sole roughage with a grain ration of 2.44 pounds of corn and 1.91 pounds of cottonseed meal per head daily.

⁵ The steers had to be fed on 24 stormy days, when the grass was covered with snow. During this time each steer consumed a total of 183 pounds of stover and 58.5 pounds of ear corn, which is charged against the cost of wintering.

⁶ The steers had to be fed 14 days on account of bad weather. They consumed about 2 pounds of ear corn and 8 pounds of roughage per head per day during that time, which was charged in cost of wintering.

The first section of Table 2 presents the results for 1913-14, when all the cattle were given a very light ration. In the winter of 1913-14 the "dry-fed" cattle (Lot 1) were given a total of 276 pounds of ear corn and 1,250 pounds of corn stover and hay per steer, or a daily ration of 2.15 pounds of ear corn and 9.76 pounds of corn stover and hay. The "silage-fed" cattle in Lot 2 received a total of 2,041 pounds corn silage and 665 pounds corn stover and hay per steer, or a daily feed of 15.95 pounds silage and 5.19 pounds of corn stover and hay.

The cattle in Lot 3, fed like those in Lot 2, were given a total of 2,006 pounds of corn silage and 605 pounds corn stover and hay



FIG. 3.—Character of winter pasture and cattle (Lot 4, 1913-14).

per steer, or a daily feed of 16.31 pounds of corn silage and 4.92 pounds of corn stover and hay. During 15 days of the winter when the grass was entirely covered with snow it was necessary to feed the steers of Lot 4 some dry feed. They were given 88 pounds of hay per steer during this time. This was the only feed these cattle received other than the pasture during the entire winter.

The second section of Table 2 shows the average daily ration and the total feed consumed per steer during the winter of 1914-15, the second year of the experiments. The cattle in Lot 1 consumed 391 pounds of ear corn and 1,434 pounds of corn stover, hay, and straw per steer, or a daily ration of 2.99 pounds of ear corn, and 10.95 pounds of corn stover, hay, and straw.

The cattle in Lot 2 were given a total of 1,807 pounds of corn silage and 789 pounds of corn stover, hay, and straw per steer, or a daily ration of 6.03 pounds of corn stover, hay, and straw, and 13.8 pounds of corn silage per steer.

The cattle in Lot 3 were given practically the same amounts of feed as those in Lot 2. The daily ration consisted of 6.04 pounds of corn stover, hay, and straw, and 13.11 pounds of corn silage per steer. The winter-grazed cattle in Lot 4 were fed a total of 183 pounds of corn stover, hay, and straw, and 58.5 pounds of ear corn per steer. The weather during this winter was very severe at times and the steers in this lot were fed 24 days on account of snows.



FIG. 4.—Steers after wintering on pasture (Lot. 4, 1914-15).

The third section of Table 2 shows the average daily ration and total amount of feed consumed for the winter of 1915-16. During this year the steers in Lot 1 got an average daily ration of 3.14 pounds of ear corn and 11.41 pounds of corn stover, hay, and straw. The steers in Lots 2 and 3 got the same amounts of feed or a daily ration of 18 pounds of corn silage and 6 pounds of corn stover, hay, and straw per steer. The winter-grazed cattle (Lot 4) were fed 29 pounds of ear corn and 128 pounds of corn stover, hay, and straw per steer during the bad weather, which extended over a period of 14 days during the winter.

TOTAL AND DAILY GAINS DURING WINTER.

Table 3 shows the average total gains and the daily gains made per steer during each of the three winters, 1913-14, 1914-15, and 1915-16.

TABLE 3.—*Total and daily gains during three winters.*

1913-14.

Lot No.	Number of steers.	Number of days.	Ration.	Average initial weight per steer.	Average final weight per steer.	Total gain (+) or loss (-) per steer.	Daily gain (+) or loss (-) per steer.
				<i>Pounds.</i>	<i>Pounds.</i>	<i>Pounds.</i>	<i>Pounds.</i>
1	25	128	Ear corn, corn stover, and hay.....	769	741	-28	-0.22
2	25	128	Corn silage, corn stover, and hay.....	770	688	-82	- .64
3	35	123	do.....	676	592	-84	- .68
4	17	112	Winter grazed.....	515	532	+17	+ .15

1914-15.

1	24	131	Ear corn, corn stover, hay, and straw...	757	725	-32	-0.24
2	24	131	Corn silage, corn stover, hay, and straw.	738	710	-28	- .21
3	31	131	do.....	677	645	-32	- .24
4	26	131	Winter grazed.....	705	722	+17	+ .13

1915-16.

1	24	119	Ear corn, corn stover, hay, and straw..	814	779	-35	-0.29
2	24	119	Corn silage, corn stover, hay, and straw.	806	764	-42	- .35
3	33	119	do.....	770	730	-40	- .34
4	16	119	Winter grazed.....	762	788	+26	+ .22

The table shows that in 1913-14 the cattle in Lot 1, fed on ear corn, corn stover, and hay, lost during the winter a total of 28 pounds per steer, equal to a daily loss of 0.22 pound per steer. These steers made the smallest loss of any of the cattle in the barns. The cattle in Lot 2, fed corn silage, corn stover, and hay, lost 82 pounds per head, or a daily loss per steer of 0.64 pound during the winter.

The cattle in Lot 3, which were "short-aged" and lighter in weight, were wintered on the same kinds of feed as those in Lot 2. They lost practically the same per steer, showing a total loss of 84 pounds for the winter and a daily loss of 0.68 pound.

The winter-grazed cattle (Lot 4) did not lose weight, but gained 17 pounds per steer, equal to a daily gain of 0.15 pound. In comparing these cattle with those in the other lots there seemed to be a greater difference in their condition than the gains and losses indicated. The steers in Lot 4 were in splendid condition when spring came, whereas those in Lots 2 and 3 were very thin, though still strong and thrifty. However, they were thinner than many buyers of stock cattle would prefer if purchasing for shipment, as the losses in transit probably would have been greater.

During 1914-15 the cattle in Lot 1, which were fed the same as those in Lot 1 the previous year, made a total loss for 131 days during

the winter of 32 pounds per steer or a daily loss of 0.24 pound. These cattle in Lot 1 lost more than any of the cattle in the barn during this winter's work. The silage cattle in Lot 2 lost 28 pounds per steers, equal to a daily loss of 0.21 pound.

The silage cattle in Lot 3 lost practically the same per steer for the winter as those in Lot 1. The cattle in Lot 3 made a total loss per steer of 32 pounds for the winter. There was very little difference in the losses on these three lots of cattle in the barns. The steers in Lot 4 gained 17 pounds per head instead of losing weight as did those wintered in the barns.

During 1915-16 the cattle in Lot 1 were fed the same as those of Lot 1 for the two previous winters. These steers lost a total of 35 pounds per animal for the winter, representing a daily loss of 0.29 pound.

The silage cattle in Lot 2 lost 42 pounds per steer, while those in Lot 3 on the same kind of feed, lost 40 pounds per steer. The dry-fed cattle in Lot 1 this year made the smallest loss of any of the cattle in the barns. The silage cattle in Lot 2 made the largest loss. The winter-grazed cattle in Lot 4 made a gain during the winter of 26 pounds per head. These cattle were in good condition in the spring, after going through the winter on pasture.

Although the cattle in Lots 1, 2, and 3 lost some weight each year, they came through the winter in good, strong, thrifty condition, or in such condition that when put on pasture they would improve from the start and make good gains in weight during the grazing season.

COST OF WINTERING.

Stockmen are interested in the cost of wintering the cattle and their cost per hundredweight in the spring resulting from the winter feeding. This is ascertained by taking the initial cost in the fall, adding the cost of wintering, and dividing this sum by the weight in the spring. This cost in spring per hundred pounds is important to stockmen who want to graze cattle during the summer and do not know whether it would be cheaper to buy cattle in the fall and winter them or whether it would be cheaper to buy them in the spring.

Table 4 shows the number of steers, rations, number of days wintered, fall prices per hundredweight, cost to feed each steer through the winter, and spring cost per hundredweight for each of the three years.

TABLE 4.—*Cost of wintering; fall and spring prices.*

1913-14.

Lot No.	Number of steers.	Number of days wintered.	Ration.	Fall cost per cwt.	Cost to feed each steer through winter.	Spring cost per cwt.
1	25	128	Ear corn, corn stover, and hay	\$5.50	\$10.10	\$7.07
2	25	128	Corn silage, corn stover, and hay	5.50	6.97	7.17
3	35	123	do.....	5.00	6.06	6.73
4	17	112	Pasture	4.50	4.66	5.23

1914-15.

1	24	131	Ear corn, corn stover, hay, and straw	\$6.00	\$12.20	\$7.96
2	24	131	Corn silage, corn stover, hay, and straw	6.00	7.58	7.30
3	31	131	do.....	6.00	7.45	7.43
4	26	131	Pasture	6.00	6.29	6.70

1915-16.

1	24	119	Ear corn, corn stover, hay, and straw	\$6.00	\$11.08	\$7.69
2	24	119	Corn silage, corn stover, hay, and straw	6.00	6.78	7.22
3	33	119	do.....	6.00	6.78	7.25
4	16	119	Pasture	6.00	5.23	6.60

Feeds were charged for the three years at the following average prices:

Ear corn.....	\$0.83 per bushel.
Cottonseed cake.....	30.00 per ton.
Corn silage.....	3.00 per ton.
Hay.....	15.00 per ton.
Corn stover and hay.....	10.00 per ton.
Corn stover, hay, and straw.....	10.00 per ton.
Pasture.....	1.00 per head per 28-day period.

In 1913-14 the cattle in Lot 1 cost \$5.50 per hundredweight in the fall. It cost \$10.10 per steer to winter on ear corn, corn stover, and hay, making the cattle cost \$7.07 per hundredweight in the spring.

The silage cattle in Lot 2 cost \$5.50 per hundredweight in the fall and it cost \$6.97 per steer to winter them, or \$3.13 per steer less than Lot 1, but the cattle in Lot 2 lost heavily during the winter. The cost per hundredweight for Lot 2 in the spring was \$7.17, or 10 cents per hundredweight more than those in Lot 1. The cattle in Lot 3, wintered on the same kind of feeds as those in Lot 2, cost \$6.06 per steer to winter, the cost in the spring being \$6.73 per hundredweight. The initial cost of these cattle was 50 cents per hundredweight less than those in Lots 1 and 2, as they were lighter cattle. There was very little difference in the spring prices per hundredweight in the cattle in Lots 2 and 3.

The winter-grazed cattle (Lot 4) made a gain during the winter, while all the cattle in the barns lost weight. It cost \$4.66 to winter

these steers, while it cost \$10.10 per steer to winter those in Lot 1, or more than twice as much. Comparison of the spring prices shows that the steers in Lot 4 cost \$0.73 per hundredweight more in the spring than they did in the fall, while those in Lot 1 cost \$1.57 more, in Lot 2 \$1.67 more, and in Lot 3 \$1.73 more. It cost more than twice as much in every case to winter the cattle in the barns as it did to winter those on pasture when the cost of feed and the gain or loss in weight of the cattle are considered.

In 1914-15 it cost \$12.20 to winter each steer of Lot 1. The fall cost per hundredweight was \$6 and spring cost \$7.96. The silage cattle in Lot 2 cost \$7.58 per head to winter; the fall cost per hundred pounds was \$6 and the spring cost \$7.30. The silage-fed cattle in Lot 3 gave practically the same results. The cost of wintering them was \$7.45 per hundredweight. It cost \$6.29 per steer to winter the cattle in Lot 4. The spring price per hundredweight was \$6.70, or an advance of \$0.70 per hundredweight over the initial cost in the fall. The advance in the spring price per hundredweight on Lot 1 was \$1.96; on Lot 2, \$1.30, and on Lot 3, \$1.43. The winter-grazed cattle gained in weight while those in the barns lost weight.

During the winter of 1915-16 the dry-fed cattle (Lot 1) cost \$11.08 per steer to winter. The spring price of this lot was \$7.69, an advance of \$1.69 over the fall cost. The cost of wintering the silage cattle in Lots 2 and 3 was \$6.78 per steer, and the increased cost in spring was \$1.22 and \$1.25, respectively, per hundredweight. The winter-grazed cattle (Lot 4), as in previous years, cost less to winter than the cattle in the barns, and at the end of the winter they were heavier than they were the previous fall. It cost \$5.23 per steer to winter them, or an advance of only \$0.60 per hundredweight over the initial cost.

SUMMARY AND CONCLUSIONS.

Table 5 is a general summary of the three years' work.

TABLE 5.—*Summary of the three winters' work.*

Lot No.	Ration.	Year.	Gain (+) or loss (−) for winter per steer.	Initial cost per cwt.	Cost to winter per steer.	Cost in spring per cwt.	Advance in spring cost over initial cost per cwt.
			<i>Pounds.</i>				
1	Ear corn, corn stover, hay, and straw.	1913-14	—28	\$5.50	\$10.10	\$7.07	\$1.57
		1914-15	—32	6.00	12.20	7.96	1.96
		1915-16	—35	6.00	11.08	7.69	1.69
	Average.....		—32	5.83	11.13	7.57	1.74
2	Corn silage, corn stover, hay, and straw.	1913-14	—28	5.50	6.97	7.17	1.67
		1914-15	—28	6.00	7.58	7.30	1.30
		1915-16	—42	6.00	6.78	7.22	1.22
	Average.....		—51	5.83	7.11	7.23	1.40

TABLE 5.—*Summary of the three winters' work—Continued.*

Lot No.	Ration.	Year.	Gain (+) or loss (—) for winter per steer.	Initial cost per cwt.	Cost to winter per steer.	Cost in spring per cwt.	Advance in spring cost over initial cost per cwt.
3	Corn silage, corn stover, hay, and straw.	1913-14	<i>Pounds.</i> —84	5.00	6.06	6.73	1.73
		1914-15	—32	6.00	7.45	7.43	1.43
		1915-16	—40	6.00	6.78	7.25	1.25
		Average.....	—52	5.67	6.76	7.14	1.47
	4	Winter pasture.....	1913-14	+17	4.50	4.66	5.23	.73
1914-15			+17	6.00	6.29	6.70	.70
1915-16			+26	6.00	5.23	6.60	.60
Average.....			+20	5.50	5.39	6.18	.68

Some important facts brought out by the work and conclusions drawn from it are as follows:

1. The steers in Lots 1, 2, and 3 lost weight each winter, the average loss for the three years being 32, 51, and 52 pounds, respectively; while the steers in Lot 4, which were winter-grazed, gained in weight every year, making an average gain of 20 pounds per head for each of the three winters.

2. The average cost of wintering the steers on dry feeds was \$11.13 per head, while the silage-fed steers (Lots 2 and 3) cost \$7.11 and \$6.76, respectively, and the steers in Lot 4 had a charge of but \$5.39 per head against them.

3. There was a saving of over \$4 per head by using a combination of silage and dry feeds instead of using the common North Carolina ration of dry roughage with a little ear corn. This emphasizes the importance of silage as a winter feed for stocker cattle.

4. A saving of almost \$6 per head was made by using meadows for winter grazing over the method of feeding used for Lot 1.

5. It cost less than one-half as much to winter the steers of Lot 4 as it did those of Lot 1, and the steers of Lot 4 gained in weight while those of Lot 1 lost weight.

6. The average increased cost per 100 pounds of the steers in the spring over the fall cost, due to the different methods of wintering, was \$1.74 for Lot 1, \$1.40 for Lot 2, \$1.47 for Lot 3, and \$0.68 for Lot 4. In other words, the farmer who carries steers through the winter under conditions similar to those in western North Carolina can figure that steers wintered on dry feed cost about $1\frac{3}{4}$ cents a pound more by their spring weight than they did in the fall. Similarly, steers wintered on a light silage ration cost about $1\frac{1}{2}$ cents more, whereas those wintered on prepared winter pastures cost less than $\frac{3}{4}$ cent more per pound.

The actual increased "worth" or value in the spring of one lot of steers over another depends on how they put on gains the following summer. This will be discussed in Part III of this bulletin.

The value of silage as a winter feed for stocker cattle in mountainous sections is shown by these experiments. A very limited portion of the land can be used for raising crops, and as silage crops make a large tonnage of good feed per acre they will be especially valuable under such conditions.

The results show most conclusively the great importance of prepared meadows or winter pastures for wintering beef cattle. A smaller acreage of pasture was required for wintering a steer than for summer grazing the same steer. In all these experiments, during no winter was more than 2 acres required to winter a steer, and the average amount for the three years was about 1.8 acres. During the summer from 2 to 3 acres were required per steer.

The enormous areas of cut-over mountain lands and lands on which there is timber of practically no value, but which are adapted for cattle grazing can be made a source of a large income and profit without undue or unjustifiable expenditure of money if put into good, permanent pasture. These lands not only furnish excellent winter grazing, but make pastures that are equaled by few in any other part of the United States for fattening cattle during the summer months. This will be presented in Part III of this bulletin, which deals with summer fattening of cattle. The farmer who owns mountain land that has been cut over or is partly covered with timber of little value is overlooking a good opportunity to make money by not converting such lands into good permanent pastures.

II. WINTER GRAZING OF STEERS.

The chief problem in most of the grazing counties in the mountainous areas is the furnishing of sufficient feed to winter stock cattle in a satisfactory manner. Most stock raisers can graze more cattle in summer than they can winter in good condition. One object of this work, therefore, was to determine some method of wintering cattle that would make possible the maintenance of a greater number during the winter months.

The winter-grazing work proved so profitable and satisfactory from every viewpoint that it is given special consideration. The possibilities of using mountain land for winter pasture, the methods of establishing the pastures, and the results obtained from them are discussed below. The report of the results includes the total and daily gains of all the winter-grazed cattle during the three years, the cost of wintering, fall and spring values, and a summary of the whole work. By grouping these facts a more significant idea can be

obtained by the reader regarding the possibilities of this winter-grazing method under his own farm conditions.

ESTABLISHING WINTER PASTURES.

The principal method used in getting the wooded mountain land seeded to grass was as follows:

The coves and flats, which were comparatively free from rocks, were cleared first. A contract was made with the mountaineers, giving them the free use of the land for two years if they would deaden all the large trees, clear out the small brush, and put the land in cultivation, planting corn each year. The land was unfitted for any purpose other than pasture development, some of the mountainous parts being so steep that horses or other work animals could not be led straight up the sides but had to be taken up by a circuitous route. The rows were run around the side of the mountain, following the contour of the land. The land was not plowed deep, as the enormous amount of humus in the soil prevented washing and leaching. From this land from 40 to 60 bushels of corn per acre were produced. The second year, at the last cultivation of the corn, a mixture of 15 pounds of orchard grass, 4 pounds of blue grass, and 7 pounds of timothy and clover per acre, furnished by the owner of the land, were seeded broadcast through the corn. The grass seed soon produced a sod sufficiently firm to prevent any heavy erosion. The orchard grass, which proved to be the best for winter purposes, grew knee high or higher on this land by the fall of the year.

Although this method of cultivating the land in corn before seeding has proved very satisfactory, it is not necessary, as grass seed sown on burnt-over land makes good pasture if the land be dragged and harrowed after seeding. After the pastures were seeded the grass was permitted to grow through the following summer before being used for winter pasture. During this time the grasses grew up and fell over, thus protecting the roots during the winter. Young blades or shoots continued to come out during the early winter and early spring months, furnishing considerable green feed along with the cured forage.

Each year, after seeding, any undergrowth or sprouts that had come up were cut down, but the cost of this was comparatively small. However, it is not advisable to use new land for winter pasture for more than two years in succession before using it for summer pasture. Summer grazing will assist in keeping down sprouts and brush, giving the grasses a better opportunity to form a heavy sod, which is very important under mountainous conditions.

Each succeeding year some new woodland was put in cultivation on this farm in order to have new land for winter pasture and to accommodate the increased number of cattle which it was planned to put on

winter-grazing experiments. By this method the actual cash expenditures for converting the raw woodland into good permanent pasture was the cost of the small amount of seed used, plus the small cost of "sprouting" each year for two or three years. This plan can be used to advantage in nearly all parts of the mountain counties.

The pasture was charged at the rate of \$1 per steer for each 28 days.

OBJECT OF THE WORK.

The object of the winter-grazing work was:

(1) To determine the practicability of carrying stock cattle through the winter on grass alone.

(2) To determine a method of wintering that would equalize the number of cattle that could be maintained profitably through both summer and winter.

PLAN OF THE WORK.

This work covered a period of three years. The steers in each lot were kept throughout one year, or until the end of the summer grazing season, when they were sold as feeders. The cattle were bought in the fall and put on winter pasture in late fall, usually some time in December, when the summer grass gave out, which was about the same time the other cattle in the experiment were taken to the barns to be wintered.

No shelter was provided during the winter, as the coves in the mountains furnished ample protection. The cattle were given no feed except during stormy weather, when they were driven to the barn and fed a light feed of hay or ear corn, corn stover, hay, and straw. As soon as the snow melted they were taken back to pasture. In the three years' work it was found that usually there is a period of 10 days to 3 weeks that the cattle will have to be fed. In the spring the cattle in this winter-grazing work were put on summer pasture as soon as it would carry them, usually at the same time the barn-wintered cattle were taken to summer pasture.

KIND OF STEERS USED.

The cattle used in this work were all grade native steers of Short-horn, Hereford, and Angus breeding with a slight amount of Devon blood in most of them. During the first year's work, 1913-14, the steers used were not as large or as uniform as those used the two following years. The steers of the first year were mostly "short 2-year-olds"; those of the last two years were mostly 2-year-olds. All were the same in quality and condition as the cattle used in the barn wintering, with the exception of those of the first year, which were somewhat lighter in weight than the barn-wintered cattle.

AMOUNT OF PASTURE ALLOWED PER STEER.

The average amount of pasture allowed per steer for winter grazing was 2 acres, but in the summer about 3 acres were required to graze a steer to good advantage. No set rule can be given as to the number of acres required to graze a steer either in winter or summer, as the conditions, such as the slope or exposure of the land, the kind of soil, and its fertility, are so variable in the different sections. The point which the writers wish to emphasize is that less acreage is required to winter graze a stocker for maintenance than to summer graze the same steer to be furnished as a feeder or for butcher purposes. It should be remembered, however, that the object of the winter grazing is simply to maintain or rough a steer through, whereas the summer grazing is for finishing the animal, which requires from 300 to 400 pounds gain to put it in marketable condition.

GAINS DURING WINTER.

Table 6 shows the total and daily gains of the steers on winter pasture.

TABLE 6.—*Total and daily gains of steers on winter pasture.*

Year.	Number of steers.	Days wintered	Ration.	Average initial weight per head.	Average final weight per head.	Total gain per head.	Average daily gain per head.
				<i>Pounds.</i>	<i>Pounds.</i>	<i>Pounds.</i>	<i>Pounds.</i>
1913-14	17	112	Winter pasture.....	515	532	17	0.15
1914-15	26	131	do.....	705	722	17	.13
1915-16	16	119	do.....	762	788	26	.22

During the first winter, 1913-14, as shown in Table 6, the 17 steers made an average total gain of 17 pounds, or a daily gain of 0.15 pound. The second year, 1914-15, the steers made a total gain of 17 pounds per head during the winter, or an average daily gain of 0.13 pound. This shows that there was very little difference in the gains the first two winters. The last winter, 1915-16, the steers did unusually well, making a total gain per head of 26 pounds and an average daily gain of 0.22 pound. When grass came in the spring all these cattle were in good fleshy condition, but the cattle that were wintered in the barn were much thinner in flesh than they were in the fall.

COST OF WINTERING.

The cost of wintering these cattle is one of the most interesting and important factors to consider. This will vary in different localities because of the difference in pastures and cost of feeds used during snowy or stormy weather. The cost of steers per hundred

pounds in the spring, after they have been charged with the purchase price in the fall plus the cost of pasture to carry them through the winter, should be of great interest to farmers and stock raisers. This is the deciding factor as to whether it will be cheaper to purchase cattle in the fall or in the spring for grazing the following summer.

TABLE 7.—*Cost of wintering: fall and spring prices.*

Year.	Number of steers.	Pounds gain per steer for winter.	Initial cost per cwt.	Cost to winter pasture.	Cost in spring per cwt.	Advance in spring over initial cost per cwt.
1913-14.....	17	17	\$4.50	\$4.66	\$5.23	¹ \$0.73
1914-15.....	26	17	6.00	6.29	6.70	1.70
1915-16.....	16	26	6.00	5.23	6.60	1.60

¹ Average, \$0.68.

Table 7 shows that there was no great difference in the cost of wintering these cattle during the three years' work. The cattle used the first year were smaller and it did not cost as much per head to winter them, yet the advance in cost per 100 pounds in the spring over the cost in the fall was more than in the following two years' work. The average advance in cost in the spring over that in the fall was 68 cents per hundred pounds, whereas in all the winter cattle work in the barns, as shown in Part I of this bulletin, there was an advance in cost of from \$1.40 to \$1.70, or an average of \$1.55 per hundred pounds. This shows clearly the economy of providing winter pasture.

SUMMARY OF THREE YEARS' WINTER PASTURE WORK.

The steers during the winter of 1913-14 made a total gain of 17 pounds per head at an average cost of \$4.66. The next winter the average gain was the same, but the cost per steer was \$6.29. During 1915-16 the steers made the largest gains of any in the three years' work, namely, 26 pounds per head, at a cost of \$6.60. In this third winter the advance in cost per 100 pounds in the spring over the cost in the fall was \$0.60. The average for the three years was \$0.68.

CONCLUSIONS FROM WINTER-GRAZING WORK.

Much of the rough mountainous land in western North Carolina should be utilized for winter-grazing purposes. It is practically unfit for any other purpose after the merchantable timber is cut. Winter grazing and the use of the silo will enable stockmen of the mountains to handle more cattle to better advantages through both summer and winter than by the old method of wintering on dry-harvested feeds.

In the experimental work the steers gained an average of 17 pounds per head the first winter, 17 pounds the second, and 26 pounds the third, the average gain being 19 pounds per head for the three years. On the other hand, the dry-fed cattle, wintered in the barns, lost an average of 32.5 pounds per head and the silage-wintered cattle lost an average of 46 pounds during the three years.

These steers required an average of about 2 acres per head for grazing in winter, but in summer stock cattle of similar kind require about 3 acres per head to make proper gains.

The cost per steer to carry the cattle through the first winter was \$4.66, the second winter \$6.29, and the third winter \$5.23, making for the three years an average of \$5.39 per head, or approximately half what it cost to dry-feed cattle in the barns. Besides, the last-named steers lost weight.

This work shows that dry-wintered cattle must sell for an average of \$1.55 more per hundredweight in the spring than in the previous fall to compensate for the loss in weight and the cost to carry them through the winter. Instead of buying dry-wintered cattle in the spring, it would be much better for stockmen to purchase the steers in the fall if they can furnish winter pasture to carry them through to summer grass. This would mean not only cheaper but also better finished cattle the following fall.

As this work was done under average conditions and covered a period of three years, giving similar results each year, any farmer or stock raiser can expect to get the same results if proper pasture plans are made. This work is entirely practical for any stockman having rough land for pasture purposes.

These cattle were fed only during snows or stormy weather. The first winter they were fed thus 15 days, the second year 28 days, and the third year 14 days, making for the three years an average of a little less than three weeks.

Winter grazing having been found to be the best and most economical method of wintering stock cattle. On the farm where this work was done sufficient winter pasture eventually will be arranged to handle all the stock cattle in this way during the winter.

III. SUMMER FATTENING OF STEERS.

OBJECT OF WORK.

Most of the cattle in this section of North Carolina are finished on grass and sold as feeders when 2 years old. It was thought that the extra finish acquired by feeding cottonseed cake with the grass would make the cattle more readily marketable on butcher markets, making greater discrimination in the quality and finish of cattle than ordinarily is made by buyers. By making a comparison of the two

methods of finishing, the gains of the cattle and the finish acquired could be studied also in relation to the different methods by which the cattle had been wintered.

The object of the summer fattening work was to determine which was the more profitable plan, viz, to finish steers on grass alone or to finish them on grass and cottonseed cake. The steers used had been wintered on various rations, consisting of (1) ear corn, corn stover, and hay; (2) corn stover and corn silage; and (3) winter grass.

PLAN OF WORK.

Table 8 gives a clear idea of how the work was planned.

TABLE 8.—*General plan of summer fattening of steers.*

Lot No.	Average number of steers for the three years.	Method of wintering Dec. 16 to Apr. 15.	Summer feeding, approximately from Apr. 15 to Sept. 1.
1	24	Ear corn, stover, hay, and straw.....	Lot divided, 12 steers on grass, and 12 on grass and cake.
2	24	do.....	Do.
3	33	Corn silage, stover, hay, and straw.....	Grass.
4	19	Winter grazed (fed only during snows)...	Do.

The work covered a period of three years. After the steers had been wintered on the different rations as shown, they were carried through the summer on grass, or on grass with cottonseed cake. The first year all the steers in Lots 1 and 2 were fed cake with pasture. The second and third years these lots were subdivided in the spring, half in each lot being allowed grass alone, and the others a small feed of cottonseed cake in the pasture. The steers in Lots 3 and 4 were grazed without feed each summer. The steers in each lot were numbered the same during the summer as in the previous winter's work, so that the records of each lot could be followed from one fall until the next.

KIND OF STEERS USED.

The steers were the same ones used in the wintering experiments. They were mostly 2-year-old grade Shorthorns, Herefords, and Angus, with a small amount of Devon blood. The different lots were as nearly uniform in weight and quality as possible.

CHARACTER AND PRICE OF PASTURE AND COTTONSEED CAKE.

Most of the pastures used had been established for some time; they consisted of a mixture of blue grass, clover, orchard grass, timothy,

and herd's grass, which is a characteristic mixture for this part of the State. The land was rolling and hilly, some of it being very rough and steep, having some of the old dead trees standing. The pastures were charged at the rate of \$1 per steer for 28 days.

The cottonseed cake fed was high grade and was used because it is not injured in quality by the rain, the wind will not blow it about, and as the steers must chew the cake they are more likely to get an equal share of it than with cottonseed meal. The difference between the cake and meal is that the cake is unground. The cake was cracked on the farm by running it through a corn-and-cob mill. In the financial statements it is charged at actual cost for each year, but in all the comparative tables it is charged at an average cost of \$30 per ton for the three years' work.

METHOD OF FEEDING AND HANDLING STEERS.

The steers were turned on pastures in the spring as soon as the grass would carry them without injury to its subsequent growth. They were given salt once a week, and every four weeks they were driven to the scales and weighed early in the morning. As soon as weighed they were driven back to pasture, never being out more than an hour at a time.

Troughs were provided in the pasture for feeding the cottonseed cake, which was given late in the afternoon. Each steer was numbered by means of an ear tag so that individual records could be kept and the steers of each lot identified.

AMOUNT OF PASTURE AND COTTONSEED CAKE CONSUMED.

The steers were given an average of about 3 acres of pasture per steer during the summer. Table 9 shows the amount of cottonseed cake consumed in each year's work, giving the lot numbers, number of steers, number of days on feed, ration, total amount of cake eaten per steer, and daily feed per steer.

TABLE 9.—Average total and daily rations, three summers.

1914.

Lot No.	Number of steers.	Number of days on feed.	Ration.	Cottonseed cake.	
				Total consumed by each steer.	Average daily ration per steer.
				<i>* Pounds.</i>	<i>Pounds.</i>
1	25	126	Pasture and cottonseed cake.....	437	3.47
2	25	126	do.....	440	3.49
3	35	165	Pasture only.....		
4	17	177	do.....		

TABLE 9.—Average total and daily rations, three summers—Continued.

1915.

Lot No.	Number of steers.	Number of days on feed.	Ration.	Cottonseed cake.	
				Total consumed by each steer.	Average daily ration per steer.
				Pounds.	Pounds.
1-a	12	140	Pasture only.....		
1-b	12	127	Pasture and cottonseed cake.....	530	4.17
2-a	12	140	Pasture only.....		
2-b	12	127	Pasture and cottonseed cake.....	530	4.17
3	31	140	Pasture only.....		
4	26	140	do.....		

1916.

1-a	11	140	Pasture only.....		
1-b	12	140	Pasture and cottonseed cake.....	525	3.75
2-a	12	140	Pasture only.....		
2-b	12	140	Pasture and cottonseed cake.....	525	3.75
3	33	140	Pasture only.....		
4	16	140	do.....		

The first section of Table 9, giving the results of the 1914 work, shows that Lot 1 consisted of 25 steers, which were fed 126 days, getting a daily ration of 3.47 pounds of cottonseed cake per steer in addition to the grass. Lot 2 contained 25 steers, which were fed almost the same quantity of feed, or a daily ration per steer of 3.49 pounds cottonseed cake for 126 days. Lot 3 contained 35 steers, which were on pasture for 165 days without any cottonseed cake. Lot 4 contained the 17 winter-grazed steers, which were on summer pasture for 177 days without any cottonseed cake.

The second section, giving the results of the 1915 work, shows that the cattle in division "a" of Lots 1 and 2 were on pasture alone for 140 days. The cattle of division "b" of these lots were fed for 127 days with a daily ration of 4.17 pounds of cottonseed cake per steer in addition to the grass. Lots 3 and 4 (Lot 4 being the winter-grazed cattle) were on pasture 140 days without any cottonseed cake.

The third section, giving the results of the 1916 work, shows that all the steers were on pasture 140 days. The steers in division "b" of Lots 1 and 2 were given a daily ration per steer of 3.75 pounds cottonseed cake, or a total of 525 pounds for the season. The remainder of the cattle were given grass only.

TOTAL AND DAILY GAINS.

Table 10 shows the average initial and final weights per head for the steers of each lot, and the total and average daily gains per steer for the three summers.

TABLE 10.—*Total and daily gains, three summers.*

1914.

Lot No.	Number of steers.	Days on feed.	Ration.	Average initial weight per steer.	Average final weight per steer.	Total average gain per steer.	Average daily gain per steer.
				<i>Pounds.</i>	<i>Pounds.</i>	<i>Pounds.</i>	<i>Pounds.</i>
1	25	126	Pasture and cottonseed cake.....	741	1,087	346	2.75
2	25	126	do.....	688	1,054	366	2.90
3	35	165	Pasture only.....	592	972	380	2.30
4	17	177	do.....	532	860	328	1.85

1915.

1-a	12	140	Pasture only.....	708	1,137	429	3.06
1-b	12	127	Pasture and cottonseed cake.....	742	1,086	344	2.71
2-a	12	140	Pasture only.....	705	1,073	368	2.63
2-b	12	127	Pasture and cottonseed cake.....	715	1,116	401	3.15
3	31	140	Pasture only.....	646	1,013	367	2.62
4	26	140	do.....	722	1,067	345	2.46

1916.

1-a	11	.....	Pasture only.....	772	1,099	327	2.34
1-b	12	.....	Pasture and cottonseed cake.....	789	1,136	347	2.48
2-a	12	.....	Pasture only.....	759	1,105	346	2.47
2-b	12	.....	Pasture and cottonseed cake.....	768	1,138	370	2.64
3	33	.....	Pasture.....	730	1,064	334	2.39
4	16	.....	.....do.....	788	1,104	316	2.26

Section 1 of Table 10, giving the results of the 1914 work, shows the initial weight of the cattle in Lot 1 to be 741 pounds, and the final weight after 126 days to be 1,087 pounds, making a total gain per steer of 346 pounds, or a daily gain of 2.75 pounds. The steers in Lot 2 made a total gain of 366 pounds, or an average daily gain of 2.90 pounds. The grass-finished cattle in Lot 3 made an average gain of 380 pounds, or an average daily gain of 2.30 pounds. The winter-grazed cattle (Lot 4), which were much lighter cattle, made a total gain of 328 pounds per steer, or an average daily gain of 1.85 pounds for a period of 177 days. It must be remembered that the cattle in Lots 1, 2, and 3 lost heavily during the previous winter and the unusual gains on these steers were due partly to getting back the flesh lost during the previous winter, and that those in Lot 4 gained in weight during the winter. As will be shown later, the total gain on the cattle in Lot 4 from fall to fall is larger than the gain on any of the other lots of steers. This is an interesting fact in connection with winter grazing and the possibility of adapting it to all mountainous counties of North Carolina and of adjoining States.

The second section, giving the results of the 1915 work, shows that Lot 1, division "a," contained 12 steers, which made a total gain of 429 pounds, or an average daily gain of 3.06 pounds. These cattle made an unusually large gain this year. The only way to account for

it was that the pasture probably was better than that provided for the others. Division "b" of Lot 1, the cake-finished cattle, in 127 days made a total gain of 344 pounds, or an average daily gain of 2.71 pounds. Lot 2, division "a," containing the grass steers, made a

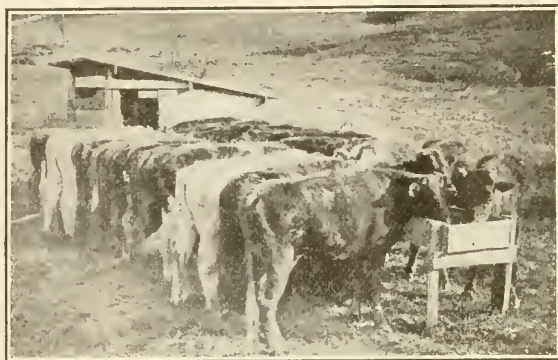


FIG. 5.—Cattle at beginning of summer fattening on pasture and cottonseed cake, 1914.

total gain of 368 pounds per steer, or an average daily gain of 2.63 pounds. Lot 2, division "b," containing the grass and cake fed steers, made a total gain per steer of 401 pounds, or an average daily gain of 3.15 pounds. Lot 3, containing the

grass-fed steers, made a total gain of 367 pounds per steer, or an average daily gain of 2.62 pounds. Lot 4, containing the winter-grazed steers, made, on grass alone during the summer, a total gain of 345 pounds per steer, or an average daily gain of 2.46 pounds. These steers, as in previous



FIG. 6.—The same steers (shown in fig. 5) when finished in August, 1914.

years, made larger gains from fall to fall than any of the other cattle. However, all the steers in the four lots made good gains during the summer.

The third section gives the total and daily gains on the 1916 work. This was an unusually good year from the standpoint of the gains

made. The steers in Lot 1, division "a," made a total gain of 327 pounds per steer, or an average daily gain of 2.34 pounds during the 140 days they were on experiment. Lot 1, division "b," containing the grass and cake finished steers, made a total gain of 347 pounds, or an average daily gain of 2.48 pounds per steer in the same length of time. Lot 2, division "a," containing the grass-fed steers, made a total gain of 346 pounds, or an average daily gain of 2.47 pounds per steer. Lot 2, division "b," containing the grass and cake finished steers, made a total gain of 370 pounds, or an average daily gain of 2.64 pounds per steer. Lot 3, containing the grass cattle, made a total gain of 334 pounds, or an average daily gain of 2.39 pounds per steer. Lot 4, containing the winter-grazed cattle, made a total gain of 316 pounds, or 2.26 pounds daily per steer for the summer. As in the two previous years' trials, steers in



FIG. 7.—Condition of steers in spring before placing on pasture and cottonseed cake (Lot 1, 1916).

Lot 4 made the largest gain from fall to fall. The cake-fed steers made larger gains, however, than any of the steers that received pasture alone.

QUANTITY AND COST OF FEED REQUIRED TO MAKE 100 POUNDS GAIN.

The cost of 100 pounds of gain will vary in different sections owing to the difference in the cost of feed. When the farmer knows how many pounds of feed are required to make 100 pounds gain he can figure easily the cost under his own conditions. The principal thing stock raisers and farmers want to know is how many pounds of gain they can expect to put on a 2-year-old steer with grass alone or with grass supplemented with cottonseed cake and the cost to make 100 pounds of gain in each case.

Table 11 shows the quantity and cost of feed required to make 100 pounds of gain.

TABLE 11.—Quantity and cost¹ of feed required for 100 pounds gain.

1914.

Lot No.	Number of steers.	Days on feed.	Ration.	Pounds of feed to make 100 pounds of gain.	Cost of feed for 100 pounds of gain.
1	25	126	Pasture and cottonseed cake.....	126	\$3.20
2	25	126	...do.....	120	3.03
3	35	165	Pasture only.....		1.55
4	17	177	...do.....		1.93

1915.

1-a	12	140	Pasture only.....		\$1.16
1-b	12	127	Pasture and cottonseed cake.....	154	3.63
2-a	12	140	Pasture only.....		1.36
2-b	12	127	Pasture and cottonseed cake.....	132	3.11
3	31	140	Pasture only.....		1.36
4	26	140	...do.....		1.45

1916.

1-a	11		Pasture only.....		\$1.53
1-b	12		Pasture and cottonseed cake.....	147	3.65
2-a	12		Pasture only.....		1.45
2-b	12		Pasture and cottonseed cake.....	142	3.48
3	33		Pasture only.....		1.50
4	16		...do.....		1.58

¹ Price of feed and pasture: Cottonseed cake, \$30 per ton; pasture, \$1 per head per 28-day period.

The first section of Table 11, giving the results of the 1914 work, shows it required 126 pounds of cottonseed cake in addition to the grass the steers in Lot 1 received to make 100 pounds gain, which cost \$3.20 per hundredweight. The cattle in Lot 2 required 120 pounds cottonseed cake fed with grass to make 100 pounds gain at a cost of \$3.03 per hundred pounds gain. The gains on the cattle in Lot 3, fed for a period of 165 days, cost \$1.55 per 100 pounds, or just about one-half as much as where cottonseed cake was fed. The winter-grazed cattle (Lot 4), which were grazed during the summer for 177 days, made 100 pounds gain at a cost of \$1.93. The gains were made much cheaper where no cottonseed cake was fed, there being very little difference in the cost of the gains in Lots 1 and 2, where cake was fed to both lots.

The second section gives the quantity and cost of feed required to make 100 pounds gain in the 1915 test. It cost \$1.16 to put 100 pounds gain on the grass-finished cattle of Lot 1, division "a," these cattle making the cheapest gain of any of the grass-fed cattle. The cattle in Lot 1, division "b," made 100 pounds gain at a cost of \$3.63, which were the most expensive gains made. The grass-finished cattle in Lot 2, division "a," made 100 pounds gain at a cost of

\$1.36. The grass and cake finished cattle in Lot 2, division "b," made 100 pounds gain at a cost of \$3.11. The grass-finished steers in Lot 3 made 100 pounds gain for the same cost as those in Lot 2, division "a," which was \$1.36 per hundred pounds. The winter and summer grazed steers made 100 pounds gain at a cost of \$1.45. This was a very cheap gain when it is considered that these steers were 17 pounds heavier in the spring than in the previous fall, whereas all the cattle in the other lots were from 28 to 32 pounds lighter in the spring than in the fall previous.

The third section gives the quantity and cost of feed required to make 100 pounds gain in the 1916 trial. The grass-finished cattle in Lot 1, division "a," made 100 pounds gain at a cost of \$1.53. The grass and cake finished steers in Lot 1, division "b," made 100 pounds gain at a cost of \$3.65, 147 pounds of cottonseed cake being fed with the grass to make this gain. The grass-finished steers in Lot 2, division "a," made 100 pounds gain at a cost of \$1.45, which was the cheapest gain made by any of the cattle during this summer's work. The grass and cake finished steers in Lot 2, division "b," required somewhat less cake to make 100 pounds gain than those in Lot 1, division "b," only 142 pounds of cake being fed to make 100 pounds gain at a cost of \$3.48. The grass-finished steers in Lot 3 made 100 pounds gain at a cost of \$1.50. The winter and summer grazed steers (Lot 4) made 100 pounds gain during the summer at a cost of \$1.58. This was a very cheap gain when it is considered that these cattle were 26 pounds heavier in the spring than in the fall previous, and that steers in the other lots had lost 30 to 40 pounds per head during the winter and would consequently make more rapid gains during the summer season.

SUMMARY OF THE THREE YEARS' WORK, INCLUDING WINTER AND SUMMER.

In order to make the combined winter and summer work for the three years clear, a general summary (Table 12) has been prepared, giving the rations, gain or loss for the winter per steer, gain for the summer per steer, total gain for the year, total cost per pound gain, total cost per steer both winter and summer; and total profit per steer, including manure. In Lot 4, where the cattle were on pasture all winter, the manure was not included in figuring the profit per steer. The feeds in Table 12 were figured at the average cost for the three years.

TABLE 12.—*Summary of three years' work, winter and summer.*

Lot No.	Ration.	Year.	Gain (+) or loss (—) for winter per steer.	Gain for summer per steer.	Total gain over fall weight per steer.	Cost per pound of yearly gain.	Total cost per steer.	Total profit per steer, including manure.
			<i>Pounds.</i>	<i>Pounds.</i>	<i>Pounds.</i>			
1-a	Winter: Ear corn, stover, and hay. Summer: Grass.	1913-14	(¹)					
		1914-15	-32	429	397	\$0.043	\$17.20	\$20.62
		1915-16	-35	327	292	.055	16.08	16.84
	Average.....		-33	378	344	.048	16.64	18.73
1-b	Winter: Ear corn, stover, and hay. Summer: Grass and cake.	1913-14	-28	346	318	.066	21.16	22.75
		1914-15	-32	344	312	.079	24.70	14.36
		1915-16	-35	347	312	.096	30.13	12.45
	Average.....		-32	345	314	.074	25.33	19.85
2-a	Winter: Silage, stover, and hay. Summer: Grass.	1913-14	(¹)					
		1914-15	-28	368	340	.037	12.58	20.30
		1915-16	-42	346	302	.039	11.78	21.83
	Average.....		-35	357	321	.038	12.18	21.06
2-b	Winter: Silage, stover, and hay. Summer: Grass and cake.	1913-14	-32	366	334	.064	18.07	23.23
		1914-15	-28	401	373	.054	20.07	24.10
		1915-16	-42	370	328	.078	25.83	16.31
	Average.....		-51	379	328	.065	21.32	21.54
3	Winter: Silage, stover, and hay. Summer: Grass.	1913-14	-34	380	346	.040	11.94	24.31
		1914-15	-32	367	335	.037	12.45	19.87
		1915-16	-40	334	294	.047	11.78	21.12
	Average.....		-52	360	308	.039	12.06	21.77
4	Winter: Pasture. Summer: Pasture.....	1913-14	17	328	345	.032	10.98	22.75
		1914-15	17	345	362	.031	11.29	22.18
		1915-16	26	316	342	.030	10.23	22.16
	Average.....		20	330	350	.031	10.80	22.16

¹ All the steers in Lots 1 and 2 during 1914 were fed cottonseed cake and pasture.² No manure included.

Table 12 shows that the steers in Lot 1, division "a," were wintered each year on ear corn, corn stover, and hay. During the summer they were on grass alone. These steers lost an average of 33 pounds per steer each winter for the three years. During the summer they made an average total gain of 378 pounds, or a total gain over the initial fall weight of 344 pounds, at an average total cost of \$16.64 per steer. They made an average profit per steer of \$18.73, the total average cost per pound of gain being \$0.048.

The steers in Lot 1, division "b," wintered the same as those in Lot 1, division "a," but fed cottonseed cake on grass during the summer, lost 32 pounds per steer during the winter. The average total gain during the summer was 345 pounds, or a total gain per steer over the initial fall weight of 314 pounds. The total cost per steer was \$25.33, showing an average profit per steer of \$19.85, the total average cost per pound of gain being \$0.074.

The steers in Lot 2, division "a," wintered on corn silage, corn stover, hay, and straw, and getting grass alone during the summers, lost on an average 35 pounds per steer during the winter. The aver-

age gain for the summer was 357 pounds per steer, the average total gain over initial weight of 321 pounds, the average total cost per steer \$12.18, showing an average profit of \$21.06 per steer, the total average cost per pound gain being \$0.038.

The steers in Lot 2, division "b," were wintered the same as those in Lot 2, division "a," and were given cake in addition to grass during the summers. These steers lost an average during the winter of 51 pounds per head. They made an average gain for the summer of 379 pounds, or a total gain over initial weight of 328 pounds. The average total cost was \$21.32 per steer, showing an average profit of \$21.54 per steer, the total cost per pound of gain being \$0.065.

The steers in Lot 3 were wintered the same as those in Lot 2, on corn silage, corn stover, hay, and straw, and summered on grass without cake. These cattle lost an average of 52 pounds per head during the winter, and made an average total gain during summers of 360 pounds, or a total gain over initial fall weight of 308 pounds at an average total cost of \$12.06, showing an average profit of \$21.77. The total cost per pound of gain was \$0.039.

The cattle in Lot 4 were grazed both winter and summer. It is very interesting to study the results of this work, as these cattle gained an average of 20 pounds per steer during each winter for the three years. The total gain for the summer averaged 330 pounds per steer, or a total gain over the initial fall weight of 350 pounds at an average total cost of \$10.80, showing an average profit of \$22.36 per steer, exclusive of the value of the manure. The total cost per pound gain was \$0.031.

CONCLUSIONS.

During the first two summers' work the feeding of cottonseed cake to steers on grass was profitable. During the last year's work, owing to the high price of the cake, it did not pay. Considering this fact and the high price that feeders have been selling for, the feeding of cottonseed cake on grass will not prove sufficiently profitable to recommend it as a general practice. It should be understood, however, that this applies to conditions similar to those where this work was conducted, that is, where the steers can get an abundance of excellent blue grass.

Winter grazing not only proved to be the most satisfactory method of wintering stock cattle, producing a substantial gain each year, but it was the cheapest method tried in any of the wintering work. In addition to this, these winter-grazed cattle made the largest total gain for the year and at less cost per head than any of the steers wintered in the barns.

These winter-grazed cattle also made a larger average profit than any of the other lots of cattle. Not including the manure, the total

profit was \$22.36 per head. Allowing a credit of \$4 per steer for the manure during the winter, the profit was \$26.36 per head. This proved to be one of the most favorable and satisfactory methods of handling cattle during both winter and summer.

The winter-grazed cattle cost the least per head, both winter and summer, this being \$10.80, or \$1.26 less per head than the steers in Lot 3, which made the next most economical showing and whose total profit was \$21.77 per head.

The results of three years' work show that steers which have been fed silage heavily during the winter, make practically as good gains the following summer on pasture as steers wintered solely on dry feeds. The total average gain of the silage-wintered steers from fall to fall was 319 pounds, while the dry-fed steers made a total average gain of 329 pounds per head. Considering that the dry-fed cattle were somewhat the better in quality, there is not enough difference in the gains to show that silage-wintered cattle do not thrive well the following summer.

The results show conclusively the value of winter pasture when combined with summer pasture. The total average gain from fall to fall on these cattle was 350 pounds, which was made at a cost of \$0.031 per pound. The winter-grazed cattle did well on summer grass and on the average were better cattle when finished in the fall than those wintered in the barns.

The next most economical showing was made by the cattle wintered on silage, stover, and hay, followed by grass in summer. The average cost per pound gain was \$0.039 for the total gain made from fall to fall. This shows the value of silage in wintering stocker cattle.

The dry-wintered cattle which were finished on grass alone the next summer made an average gain of 344 pounds per steer at an average cost of \$0.048 per pound, which was practically 1 cent per pound more for the total gains made than the silage-wintered cattle.

The cattle wintered on silage, corn stover, and hay and finished on grass and cake made an average total gain from fall to fall of 328 pounds at a cost of \$0.065 per pound, whereas the cattle wintered on the same ration but finished on grass alone made their gains at a cost of \$0.038 per pound. This shows that the silage and grass combination during winter and summer, respectively, is the more satisfactory, considering the cost of the gains.

The steers wintered on a dry ration of ear corn, corn stover, and hay and finished during the summer on grass and cottonseed cake made a total gain of 314 pounds from fall to fall at an average cost of \$0.074 per pound. This was the most expensive gain produced. It is interesting to note in this connection that this is the common

method of wintering stock cattle in the mountains of North Carolina and of surrounding States.

Considering the combination where the cattle were dry-wintered on ear corn, corn stover, and hay and finished on grass alone, the average cost per pound for the total gain made from fall to fall was \$.048. The difference between the ration fed in this case and that presented in the foregoing paragraph was the elimination of the cottonseed cake during the summer, which reduced the cost per pound of gain from \$.074 to \$.048. These figures show that the combination of dry wintering with grass during the summer produced the least economical gains from fall to fall. The important conclusion to be drawn from these figures is that, where winter pasture can not be provided, cattle wintered on corn silage with dry roughage and finished on grass make the cheapest gains.

FINANCIAL STATEMENTS.

In connection with the following yearly financial statements it should be remembered that the figures apply to the local conditions where the work was conducted. There are a great many factors which will make financial statements vary, such as the initial cost and selling price of the steers, cost of the various feeds, and cost of pasture. The statements presented below show that all the cattle made a profit, the great value of winter pasture being especially prominent in this connection.

TABLE 13.—*Financial statement, 1913-14.*

Lot 1. Wintered 128 days on ear corn, corn stover, and hay. Finished on pasture and cottonseed cake 126 days:	
To 25 steers, 19,235 pounds, at \$5.50 per cwt.....	\$1,057.92
To wintering 25 steers, at \$8.80 per cwt.....	220.00
To pasture 126 days, at \$1 per 28 days.....	112.50
To 10,932 pounds cottonseed cake, at \$30.....	163.98
Total expenditures.....	1,554.40
By sale of 25 steers, ¹ 27,170 pounds, at \$7.75.....	2,105.67
By value of 25 tons manure, at \$2 per ton.....	50.00
Total receipts.....	2,155.67
Total profit, including manure.....	601.27
Total profit, not including manure.....	551.27
Average profit per steer, including manure.....	24.05
Average profit per steer, not including manure.....	22.05

¹ This lot was sold in Asheville, N. C., at home weights. No slaughter or shrinkage data secured.

Lot 2. Wintered 128 days on corn silage, corn stover, and hay. Fattened on pasture and cottonseed cake 126 days:

To 25 steers, 19,250 pounds, at \$5.50 per cwt.	\$1,058.75
To wintering 25 steers, at \$6.96 per cwt.	174.00
To pasture of 25 steers, 126 days, at \$1 per 28 days.	112.50
To 11,004 pounds cottonseed cake, at \$30 per ton.	165.06
Total expenditures	1,510.31
By sale of 25 steers, ¹ 26,340 pounds, at \$7.75.	2,041.35
By value of 25 tons manure, at \$2 per ton.	50.00
Total receipts	2,091.35
Total profit, including manure.	581.04
Total profit, not including manure.	531.04
Average profit per head, including manure.	23.24
Average profit per head, not including manure.	21.24

Lot 3. Wintered 123 days on corn silage, corn stover, and hay. Finished on pasture alone, 165 days:

To 35 steers, 23,665 pounds at \$5 per cwt.	1,183.25
To wintering 35 steers at \$6.05 per cwt.	211.75
To pasture, 165 days at \$1 per 28 days.	206.25
Total expenditures	1,601.25
By sale of 35 steers, ² 34,030 pounds at \$7.	2,382.10
By value of 35 tons manure at \$2 per ton.	70.00
Total receipts	2,452.10
Total profit including manure.	850.85
Total profit not including manure.	780.85
Average profit per head including manure.	24.31
Average profit per head not including manure.	22.31

Lot 4. Wintered on range 112 days. Finished on pasture only, 177 days:

To 17 steers, 8,765 pounds at \$4.50 per cwt.	394.42
To wintering 17 steers at \$4.66 per head.	79.22
To summer pasture, 177 days at \$1 per 28 days.	107.44
Total expenditures	581.08
By sale of 17 steers, ² 14,630 pounds at \$6.50.	950.95
Total receipts	950.95
Total profit, 17 steers.	369.87
Average profit per head.	21.75
Prices charged for feeds in 1913-14:	
Ear corn	per bushel . 50
Cottonseed cake	per ton 30.00
Corn silage	do 3.00
Corn stover and hay	do 10.00
Hay (alone)	do 15.00

¹ This lot was sold in Asheville at home weights. No shrinkage or slaughter data secured.

² This lot sold as feeders.

TABLE 14.—*Financial statement, 1914-15.*

Lot 1-a. Wintered on ear corn, stover, and hay ; finished on pasture :	
To 12 steers, 8,750 pounds, at \$6 per cwt-----	\$525. 00
To wintering 12 steers, 131 days, at \$12.75 each-----	153. 00
To pasture charges, 140 days, at \$1 per 28 days-----	60. 00
Total expenditures-----	738. 00
By sale of 12 steers, 13,640 pounds, at \$7-----	954. 80
By value of 12 tons manure, at \$2 per ton-----	24. 00
Total receipts-----	978. 80
Total profit, including manure-----	240. 80
Total profit, not including manure-----	216. 80
Average profit per head, including manure-----	20. 06
Average profit per head, not including manure-----	18. 06
Lot 1-b. Wintered on ear corn, corn stover, and hay. Summer fat- tened on grass and cottonseed cake :	
To 12 steers, 9,420 pounds, at \$6 per cwt-----	565. 20
To wintering 12 steers, 131 days, at \$12.75 each-----	153. 00
To pasture charges, 127 days, at \$1 per 28 days-----	54. 48
To 6,360 pounds cottonseed cake, at \$25 per ton-----	79. 50
Total expenditures-----	852. 18
By sale of 12 steers, 13,030 pounds, at \$7.75-----	1, 009. 82
By value of 12 tons of manure, at \$2 per ton-----	24. 00
Total receipts-----	1, 033. 82
Total profit, including manure-----	181. 64
Total profit, not including manure-----	157. 64
Average profit per head, including manure-----	15. 13
Average profit per head, not including manure-----	13. 13
Lot 2-a. Wintered on corn silage, stover, and hay. Fattened on pas- ture alone :	
To 12 steers, 8,850 pounds, at \$6 per cwt-----	\$531. 00
To wintering 12 steers, 131 days, at \$7.58 each-----	90. 96
To pasture, 140 days, at \$1 per 28 days-----	60. 00
Total expenditures-----	681. 96
By sale of 12 steers, 12,880 pounds, at \$7-----	901. 60
By value of 12 tons of manure, at \$2 per ton-----	24. 00
Total receipts-----	925. 60
Total profit, including manure-----	243. 64
Total profit, not including manure-----	219. 64
Average profit per head, including manure-----	20. 30
Average profit per head, not including manure-----	18. 30

Lot 2-b. Wintered on silage, stover, and hay. Finished on pasture and cottonseed cake:

To 12 steers, 8,860 pounds, at \$6 per cwt-----	\$531. 60
To wintering 12 steers, 131 days, at \$7.58 each-----	90. 96
To pasture for 12 steers, 127 days, at \$1 per 28 days-----	54. 48
To 6,360 pounds cottonseed cake, at \$25 per ton-----	79. 50

Total expenditures-----	<u>756. 54</u>
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By sale of 12 steers, 13,390 pounds, at \$7.75-----	1,037. 72
By value of 12 tons manure, at \$2 per ton-----	24. 00

Total receipts-----	<u>1,061. 72</u>
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Total profit, including manure-----	305. 18
Total profit, not including manure-----	281. 18
Average profit per head, including manure-----	25. 43
Average profit per head, not including manure-----	23. 43

Lot 3. Wintered on silage, stover, and hay. Finished on pasture alone:

To 31 steers, 21,000 pounds at \$6 per cwt-----	1,260. 00
To wintering, 131 days at \$7.45 each-----	230. 95
To pasture, 140 days at \$1 per 28 days-----	155. 00

Total expenditures-----	<u>1,645. 95</u>
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By sale of 31 steers, 31,430 pounds at \$7 per cwt-----	2,200. 10
By value of 31 tons manure, at \$2 per ton-----	62. 00

Total receipts-----	<u>2,262. 10</u>
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Total profit, including manure-----	616. 15
Total profit, not including manure-----	554. 15
Average profit per head, including manure-----	19. 87
Average profit per head, not including manure-----	17. 87

Lot 4. Winter grazed. Finished on pasture alone:

To 26 steers, 18,330 pounds at \$6 per cwt-----	1,099. 80
To wintering 26 steers 131 days at \$6.41 each-----	166. 66
To pasture, 140 days, at \$1 per head for 28 days-----	130. 00

Total expenditures-----	<u>1,396. 46</u>
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By sale of 26 steers, 27,760 pounds at \$7 per cwt-----	1,943. 20
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Total receipts-----	<u>1,943. 20</u>
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Total profit on 26 steers-----	546. 74
Average profit per steer-----	21. 03

Prices of feeds charged in 1914-15:

Ear corn-----per bushel--	1. 00
Cottonseed cake-----per ton--	25. 00
Corn stover, hay, and straw-----do--	10. 00

TABLE 15.—*Financial statement, 1915-16.*

Lot 1-a. Wintered on ear corn, stover, hay, and straw. Finished on pasture:

To 11 steers, ¹ 8,940 pounds at \$6 per cwt.....	\$536. 40
To wintering 11 steers, 119 days at \$12.13 each.....	133. 43
To pasture, 140 days at \$1 per 28 days.....	55. 00
Total expenditures.....	<u>724. 83</u>
By sale of 11 steers, 12,090 pounds at \$7.25.....	876. 52
By value of 11 tons manure at \$2.....	22. 00
Total receipts.....	<u>898. 52</u>
Total profit including manure.....	173. 69
Total profit not including manure.....	151. 69
Average profit per head including manure.....	15. 79
Average profit per head not including manure.....	<u>13. 79</u>

Lot 1-b. Wintered on ear corn, stover, hay, and straw. Finished on pasture and cottonseed cake:

To 12 steers, 9,730 pounds at \$6 per cwt.....	583. 80
To wintering 12 steers, 119 days at \$12.13 each.....	145. 56
To pasture, 140 days at \$1 per 28 days.....	60. 00
To cottonseed cake, 6,540 pounds at \$35 per ton.....	114. 45
Freight, Clyde to Baltimore.....	46. 68
Feed in transit to Spencer, N. C.....	1. 75
Feed and insurance in yards at Baltimore.....	12. 05
Commission charges.....	10. 00
Total expenditures.....	<u>974. 29</u>
By sale of 12 steers, 13,100 pounds at \$8.25.....	1, 070. 75
By value of 12 tons manure at \$2.....	24. 00
Total receipts.....	<u>1, 094. 75</u>
Total profit including manure.....	120. 46
Total profit not including manure.....	96. 46
Average profit per steer including manure.....	10. 03
Average profit per steer not including manure.....	<u>8. 03</u>

Lot 2-a. Wintered on corn silage, corn stover, hay and straw. Finished on grass:

To 12 steers, 9,700 pounds at \$6 per cwt.....	582. 00
To wintering 12 steers, 119 days at \$6.78 each.....	81. 36
To pasture, 140 days at \$1 per 28 days.....	60. 00
Total expenditures.....	<u>723. 36</u>
By sale of 12 steers, 13,260 pounds at \$7.25 per cwt.....	961. 31
By value of 12 tons manure at \$2 per ton.....	24. 00
Total receipts.....	<u>985. 31</u>

¹ This lot was started with 12 steers, but one of them died, so only 11 were used.

Lot 2-a—Continued.

Total profit including manure.....	\$261.95
Total profit not including manure.....	237.95
Average profit per head including manure.....	21.83
Average profit per head not including manure.....	19.83

Lot 2-b. Wintered on corn silage, corn stover, hay, and straw.

Finished on grass and cottonseed cake:

To 12 steers, 9,640 pounds at \$6 per cwt.....	578.40
To wintering 12 steers, 119 days at \$6.78 each.....	81.36
To pasture, 140 days at \$1 per 28 days.....	60.00
To cottonseed cake, 6,540 pounds at \$35 per ton.....	114.45
Freight, Clyde to Baltimore.....	46.68
Feed in transit to Spencer, N. C.....	1.75
Feed and insurance in yards, Baltimore.....	12.05
Commission charges.....	10.00

Total expenditures.....	904.69
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By sale of 12 steers, 12,850 pounds at \$8.25.....	1,060.12
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By value of 12 tons of manure at \$2.....	24.00
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Total receipts.....	1,084.12
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Total profit including manure.....	179.43
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Total profit not including manure.....	155.43
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Average profit per head including manure.....	14.95
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Average profit per head not including manure.....	12.95
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Lot 3. Wintered on corn silage, stover, hay, and straw. Finished on pasture:

To 33 steers, 25,415 pounds at \$6 per cwt.....	1,524.90
To wintering 33 steers, 119 days at \$6.78 each.....	223.74
To pasture, 140 days at \$1 per 28 days.....	165.00

Total expenditures.....	1,913.64
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By sale 33 steers, 35,100 pounds at \$7.25.....	2,544.75
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By value of 33 tons of manure at \$2 per ton.....	66.00
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Total receipts.....	2,610.75
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Total profit, including manure.....	697.11
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Total profit, not including manure.....	631.11
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Average profit per steer, including manure.....	21.12
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Average profit per steer, not including manure.....	19.12
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Lot 4. Winter grazed and summer grazed:

To 16 steers, 12,195 pounds at \$6 per cwt.....	730.80
To winter pasture, 119 days at \$1 per 28 days.....	68.00
To feed during snows at \$1.05 per head.....	16.80
To summer pasture, 140 days at \$1 per 28 days.....	80.00

Total expenditures.....	895.60
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By sale of 16 steers, 17,670 pounds at \$7.25 per cwt.....	1,281.07
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Total receipts.....	1,281.07
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Lot 4—Continued.

Total profit on 16 steers.....	\$385.47
Average profit per steer.....	24.09
Prices of feeds charged in 1915-16:	
Ear corn.....per bushel..	1.00
Cottonseed cake.....per ton..	35.00
Corn silage.....do.....	3.00
Hay, stover, and straw.....do.....	10.00

SLAUGHTER DATA.

At the close of the first year's work the cake-fed steers in Lots 1 and 2 were sold to local butchers in Asheville. They were killed at different times, so the slaughter data were not obtainable. The same applies to these lots in the second year's work, 1914-15. They were sold to a prominent North Carolina resort owner, who continued to feed them during the winter to supply the hotels, a few being killed at a time.

The cake-fed steers in Lots 1 and 2 in 1916 were shipped direct to market and the shipping and slaughter data are given in Table 16.

TABLE 16.—*Shipping and slaughter data, 1915-16.*

Item.	Lot 1-b.	Lot 2-b.
Number of steers.....	12	12
Final weight on farm Sept. 5.....pounds..	1,149	1,158
Weight at railroad station Sept. 5.....do.....	1,108	1,099
Shrinkage in driving to railroad.....do.....	41	59
Do.....per cent.....	3.57	5.1
Selling weight.....pounds.....	1,092	1,071
Total net shrinkage in transit.....do.....	57	87
Do.....per cent.....	4.96	7.51
Dressing percentage on farm weight.....do.....	52.24	52.59
Dressing percentage on market weight.....do.....	54.99	56.97

These cattle were driven 15 miles to the railroad station, where they were watered and then loaded on cars. They were shipped September 5. They arrived in Baltimore September 8 and were sold on the market September 11. All the cattle summered on grass were sold as feeders, so that only a very small number of slaughter data were obtained from the summer work.

Table 16 shows that the steers in Lot 1-b, wintered on dry feed, lost 57 pounds in transit, and the steers in Lot 2-b, wintered on corn silage, lost 87 pounds in transit. This difference is accounted for by the fact that the winter dry-fed cattle took a greater fill of water than those in Lot 2. The steers in Lot 1 had been accustomed to drinking out of water troughs at the farm, and when they reached Baltimore they took more water than Lot 2, which had drunk out of the branch both winter and summer. Although the silage-fed cattle lost more in transit, it will be noticed that their dressing percentage was higher on both market and home weights than that of the steers in Lot 1.

IV. WINTER FATTENING OF STEERS.

In the mountain districts of western North Carolina and adjacent sections of other States it has been the custom for farmers and stockmen to sell their steers in the fall of the year as feeders. When it is taken into consideration that some of these farmers raise considerable feed, such as corn, hay, and straw, which is often not used most advantageously, and that the cattle handled under the usual methods furnish little manure for the cultivated fields, the feasibility of profitably finishing out a large number of these steers for the block is a question that at once presents itself. Many farmers of this section have desired information concerning the values of home-grown feeds, especially silage and other roughages, as well as the use of cottonseed meal and cottonseed hulls for fattening steers.

The following-described experiments were carried out to furnish dependable information of this sort and to illustrate methods of feeding and handling steers on feed in the dry lot, besides affording a comparison between selling steers as finished beeves and as feeders.

EXPERIMENTS OF 1913-14.

These experiments were conducted for the purpose of determining whether steers in this region could be fattened profitably during winter months for the market, and of comparing this method of disposing of the steers with the usual practice of selling them as feeders in the fall. It was desired also to obtain information as to what feeds usually would prove most efficient and profitable in finishing mature steers under farm conditions in these mountain regions.

These objects involve a consideration of the methods best adapted for handling the steers, the use of native feeds ordinarily available, as well as the use of cottonseed meal and cottonseed hulls, which must be shipped in, and a study of the problems connected with marketing the finished cattle.

PLAN OF THE WORK.

The work was carried out under average farm conditions for the section, and the care and attention given it were such as any good farmer should employ in doing similar work for himself. The cattle were divided into two lots of 12 steers each and were given the same care and management. The steers in Lot 1 were fed a ration of cottonseed meal, cottonseed hulls, and a mixture of corn stover and hay, while those of Lot 2 were fed cottonseed meal, ear corn, and cottonseed hulls, with corn stover and hay. The steers were fed from November 17, 1913, to March 9, 1914, a total of 113 days.

KIND OF STEERS USED.

All the steers were representative native cattle of western North Carolina, averaging 2 years old, and had been secured from Haywood, Madison, and Buncombe Counties. None of them was a pure bred. Most of them were Shorthorn, Hereford, and Angus grades; some were grade Devons; and a few showed traces of dairy breeding. They were uniform in size and were divided into two lots as equally as possible according to weight, quality, and condition.

CHARACTER AND PRICES OF FEEDS USED.

All the feeds used were valued at standard market prices. The cottonseed meal was of good quality, analyzing about 38.6 per cent crude protein, and cost \$30 per ton delivered at the farm. The cottonseed hulls were bought and delivered in car lots for \$7.50 per ton and were a good grade of loose hulls.

The ear corn used was not of good quality, as it had been frosted before maturing and was soft. Its market value was very low, but it was charged against the steers at 50 cents per bushel of 70 pounds.

The corn stover was of average grade and had been frosted before it was cut. It was valued at \$5 per ton.

The hay used was good bright hay made from a mixture of timothy, herd's grass, clover, and orchard grass, and was valued at \$15 per ton. The hay and corn stover were mixed in equal quantities and run through a feed cutter before being fed. This mixture was charged against the cattle at \$10 per ton.

METHOD OF FEEDING AND HANDLING.

During the fattening period the steers were kept in barns, and for about 30 minutes twice each day were allowed to run in open lots, where they had access to water. They were fed at 8 o'clock in the morning and at 5 o'clock in the afternoon. The cottonseed meal and cottonseed hulls were mixed thoroughly in the troughs before the steers were turned to the feed. The ear corn was mixed with the hulls and meal. The mixture of corn stover and hay was fed after the meal and hulls had been eaten and after the steers had taken their fill of water. Comparatively small quantities of cottonseed meal and corn were fed to the steers at the start of the test, so as not to get any of them "off feed."

The cattle were weighed every 28 days, early in the morning before feed or water was given. The initial and final weights were averaged from the weights obtained for three consecutive days.

AMOUNTS OF FEED CONSUMED AND AVERAGE DAILY RATIONS.

Table 17 shows the total amount of feed eaten by each steer and the average daily ration per head by periods and for the total period.

TABLE 17.—*Feeds consumed and average daily rations, Nov. 17, 1913, to Mar. 9, 1914, 113 days.*

Lot No.	Number of steers.	Days fed.	Ration.	Total feed consumed per steer.	Average daily rating by periods.				Average daily ration for entire period.
					First period, 29 days.	Second period, 28 days.	Third period, 28 days.	Fourth period, 28 days.	
1	12	113	Cottonseed meal.....	<i>Pounds.</i> 744	<i>Pounds.</i> 4.02	<i>Pounds.</i> 6.96	<i>Pounds.</i> 7.50	<i>Pounds.</i> 7.95	<i>Pounds.</i> 6.85
			Cottonseed hulls.....	1,881	16.04	17.00	16.57	17.00	16.65
			Corn stover and hay.....	458	5.00	3.33	3.33	4.52	4.05
2	12	113	Cottonseed meal.....	535	3.25	4.91	5.00	5.84	4.73
			Ear corn.....	710	4.32	6.87	7.00	7.00	6.28
			Cottonseed hulls.....	1,828	16.04	16.61	15.61	16.46	16.17
			Corn stover and hay.....	338	4.77	2.62	2.06	2.47	2.99

During the first period of 29 days each steer in Lot 1 ate an average of 4.02 pounds of cottonseed meal, 16.04 pounds of hulls, and 5 pounds of corn stover and hay. The allowance of cottonseed meal was gradually increased until the last period, when they consumed 7.95 pounds of cottonseed meal per head daily. The roughage was supplied in such quantities as the cattle would eat, and it can be seen from the table that there was little variation from month to month. The average daily ration per head for the entire period of 113 days was 6.85 pounds cottonseed meal, 16.65 pounds of hulls, and 4.05 pounds of stover and hay.

Each steer in Lot 2 during the first 29 days ate an average daily ration of 3.25 pounds of cottonseed meal, 4.32 pounds of ear corn, 16.04 pounds of cottonseed hulls, and 4.77 pounds of hay and stover. The cottonseed meal and corn were gradually increased and the roughages slightly decreased, until during the last period each steer ate an average daily ration of 5.84 pounds of cottonseed meal, 7 pounds of ear corn, 16.46 pounds of hulls, and 2.47 pounds of hay and corn stover. The average daily ration per head for the 113 days the steers were on feed was 4.73 pounds of cottonseed meal, 6.28 pounds of ear corn, 16.17 pounds of cottonseed hulls, and 2.99 pounds of hay and stover.

It will be noted that heavy rations of roughages were fed, but that when the concentrate allowances were increased the steers would not eat as much of the hay and stover. Each lot consumed practically the same amount of cottonseed hulls, but Lot 2 used less of the hay and stover. It would appear that Lot 2 had a much heavier allowance of concentrates, but it will be recalled that the corn was light and soft and was fed in the ear.

TOTAL AND DAILY GAINS.

Table 18 shows the average initial and final weights per head for the steers in each lot, and the total and daily gains made by each steer.

TABLE 18.—*Total and daily gains, Nov. 17, 1913, to Mar. 9, 1914, 113 days.*

Lot No.	Number of steers.	Ration.	Average initial weight per steer.	Average final weight per steer.	Average total gains per steer.	Average daily gains per steer.
1	12	Cottonseed meal, cottonseed hulls, corn stover, and hay.....	Pounds. 819	Pounds. 973	Pounds. 154	Pounds. 1.36
2	12	Cottonseed meal, ear corn, cottonseed hulls, corn stover, and hay.....	823	983	160	1.42

The steers in Lot 1 made an average total gain of 154 pounds per head during the 113 days of the fattening period, while those of Lot 2 averaged 160 pounds. The average daily gains per head were 1.36 pounds for Lot 1 and 1.42 pounds for Lot 2. Considering that the steers were in good condition when the feeding began, and noting the rations fed, it can be seen that these gains, though not large, were very satisfactory. The lot of steers fed cottonseed meal and ear corn made slightly larger gains.

QUANTITY AND COST OF FEED REQUIRED FOR 100 POUNDS GAINED.

The quantity and cost of feeds required to produce 100 pounds of gain for each lot is shown in Table 19.

TABLE 19.—*Quantity and cost¹ of feed required to make 100 pounds of gain.*

Lot No.	Number of steers.	Ration.	Pounds of feed required to make 100 pounds of gain.	Cost of feed for 100 pounds of gain.
1	12	Cottonseed meal.....	483	\$13.32
		Cottonseed hulls.....	1,222	
		Corn stover and hay.....	297	
2	12	Cottonseed meal.....	334	13.92
		Ear corn.....	443	
		Cottonseed hulls.....	1,247	
		Corn stover and hay.....	211	

¹ Prices of feeds used:

Cottonseed meal.....	\$30.00 per ton.
Cottonseed hulls.....	7.50 per ton.
Ear corn.....	.50 per bushel.
Corn stover and hay mixed.....	10.00 per ton.

It required 483 pounds of cottonseed meal, 1,222 pounds of cottonseed hulls, and 297 pounds of hay and corn stover, valued at \$13.32, to produce 100 pounds of gain for the steers in Lot 1, and for those in Lot 2, 334 pounds of cottonseed meal, 443 pounds of ear corn, 1,247

pounds of cottonseed hulls, and 211 pounds of hay and stover, valued at \$13.92. Thus it is seen that considerably more concentrates were required to produce 100 pounds of gain in Lot 2, while the amount of roughage, including the cobs in the ear corn fed to Lot 2, was nearly the same for both lots. Apparently this would indicate clearly that corn was not efficient in producing gains; but it should be remembered that the corn was of poor quality.

Although the steers in Lot 2 gained more, the gains cost 60 cents per hundredweight more than in Lot 1.

The amount and cost of feed required to make 100 pounds of gain are factors of great interest to the feeder. As the prices of feeds fluctuate from year to year, the farmer, knowing the quantity and cost of feed needed to produce 100 pounds of gain, can calculate safely what gains he may expect from certain rations, and determine the approximate cost of putting the gains on his cattle under the different conditions.

Table 20 shows the average final farm and market weights per head, the shrinkage in transit to market, the carcass weights, and dressing percentages of the steers.

TABLE 20.—*Slaughter data, winter fattening of 1913-14.*

Lot No.	Ration.	Average farm weight per steer, Mar. 10.	Average market weight per steer, Mar. 16.	Average shrinkage per steer in transit.	Average weight of carcass.	Percentage of shrinkage.	Percentage dressed by farm weights.	Percentage dressed by market weights.
1	Cottonseed meal, cottonseed hulls, corn stover, and hay.....	Pounds. 973	Pounds. 892	Pounds. 81	Pounds. 485	Per cent. 8.35	Per cent. 49.9	Per cent. 54.4
2	Cottonseed meal, ear corn, cottonseed hulls, corn stover, and hay.....	983	898	85	513	8.66	52.2	57.2

In transit the steers in Lot 1 sustained a shrinkage of 81 pounds per head, while those of Lot 2 lost 85 pounds per head, so there was little difference in the shrinkage of the two lots. This excessive shrinkage is accounted for by the fact that the cattle left the farm at Springdale on March 10, 1914, were driven 10 miles over bad roads to a loading point, loaded the following morning, and shipped to Baltimore, where they arrived after a three days' trip. In addition to these disadvantages when the steers arrived at the market the weather was very cold and disagreeable, which prevented their taking a normal fill of water.

It will be noted that the carcasses of the steers of Lot 2 weighed heavier than those of Lot 1, and also dressed out better. Those in Lot 1 dressed out 54.4 per cent and those of Lot 2, 57.2 per cent by market weights. This difference in the killing conditions of the steers was detected very easily in the carcasses, as those of Lot 2

carried a greater quantity of fat, which was well distributed. The butchers estimated the steers of Lot 2 should have sold for 10 cents per hundredweight more than those of Lot 1, although it is shown in the financial statement that all the cattle brought the same price per hundredweight.

The superior finish which the steers of Lot 2 had taken on must be considered as a point in favor of the ration which they were fed. Even though it cost 60 cents more to put on 100 pounds of gain on the cattle of Lot 2, a difference of only 10 cents per hundredweight in the selling price of the steers would offset to a large extent this difference. The degree of finish, then, must be considered in planning rations for cattle, because the highly finished steers bring better prices.

Table 21 gives the financial statement of the two lots of steers. This is given merely to throw light on the financial outcome of a typical feeding operation during the season of 1913-14. The financial statement for a similar group of steers fed the same rations might be entirely different for any other year, as there are so many factors which affect it. Among these may be mentioned the initial cost of the steers, cost of various feeds, cost of gains, distance from market, and the market prices. All these factors vary a great deal in different years or even during the same year.

The manure which fattening steers produce is an important item in the business of feeding and by all means should be credited to the steers. In this work the manure was weighed and valued at \$2 per ton, which is a very conservative valuation. The value of the fertilizing constituents in a ton of this manure undoubtedly would cost much more than \$2 if they were purchased in the form of commercial fertilizers.

TABLE 21.—*Financial statement, winter fattening, November 17, 1913, to March 9, 1914, 113 days.*

Lot 1. Cottonseed meal, cottonseed hulls, corn stover, and hay:	
To 12 steers, 9,830 pounds at \$5.50 per cwt.....	\$540. 65
To 8,930 pounds cottonseed meal at \$30 per ton.....	133. 95
To 22,575 pounds cottonseed hulls at \$7.50 per ton.....	84. 66
To 5,498 pounds corn stover and hay at \$10 per ton.....	27. 49
Total cost of feed.....	246. 10
Cost of marketing	46. 50
Total expenditures.....	833. 25
By sale of 12 steers, 10,700 pounds at \$7.60 per cwt.....	813. 20
By value of 48 tons manure at \$2 per ton.....	96. 00
Total receipts	909. 20

Lot 1—Continued.

Total profit including manure.....	\$75.95
Total loss not including manure	20.05
Average profit per steer including manure.....	6.33
Average loss per steer not including manure.....	1.67

Lot 2. Cottonseed meal, ear corn, cottonseed hulls, corn stover, and hay:

To 12 steers, 9,880 pounds at \$5.50 per cwt.....	543.40
To 6,422 pounds cottonseed meal at \$30 per ton.....	96.33
To 8,516 pounds ear corn at 50 cents per bushel.....	60.82
To 21,938 pounds cottonseed hulls at \$7.50 per ton.....	82.27
To 4,060 pounds corn stover and hay at \$10 per ton.....	20.30
Total cost of feed	259.72
To cost of marketing	46.50
Total expenditures.....	849.62
By sale of 12 steers, 10,775 pounds at \$7.60 per cwt.....	\$18.90
By value of 48 tons manure at \$2 per ton.....	96.00
Total receipts	914.90
Total profit including manure.....	65.28
Total loss not including manure.....	30.72
Average profit per steer including manure.....	5.44
Average loss per steer not including manure.....	2.56

NOTE.—Steers of Lot 1 valued at market at \$7.55 per cwt.; steers of Lot 2 valued at market at \$7.65 per cwt.; all were sold in one lot at \$7.60 per cwt.

Comparing the financial statements of the two lots, it is seen that when the value of the manure is credited to the feeding, Lot 1 returned a profit of \$75.95, or an average profit per steer of \$6.33; while Lot 2 returned a profit of \$65.28, or an average profit of \$5.44 per steer. If no credit is allowed for manure produced, both lots were sold at a loss. Thus, notwithstanding the fact that the steers of Lot 1 made smaller gains, the gains were produced more economically.

EXPERIMENTS OF 1914-15.

The experiments conducted during the winter of 1914-15 were carried out with the same objects in view as the previous winter's fattening tests.

PLAN OF WORK.

The same general plans followed in the previous winter were adhered to. Four lots of steers were fed as follows:

- Lot 1, 10 steers, fed cottonseed meal, cottonseed hulls, and ear corn.
- Lot 2, 100 steers, fed cottonseed meal and cottonseed hulls.
- Lot 3, 21 steers, fed cottonseed meal and corn silage.
- Lot 4, 26 steers, fed cottonseed meal and cottonseed hulls.

The steers in the first three lots were fed for 96 days, and those in Lot 4 for 111 days.

KIND OF STEERS USED.

The steers used in the experiments of 1914-15 were native grades, 2 and 3 years of age. The 41 head making up the first three lots were better steers than those used the previous year, but those of Lot 4 were "short" 2-year-olds of about the same quality as the 24 head which were fed in 1913-14.

CHARACTER AND PRICES OF FEEDS USED.

The cottonseed meal and hulls used were of the same grade as in 1913-14 and analyzed about 38.6 per cent crude protein. The corn was good, sound, white corn, and the silage was of good average quality, made from corn that would have yielded about 40 bushels per acre.

The cottonseed meal and cottonseed hulls were bought and delivered for \$25 and \$5.50 per ton, respectively. The corn was charged against the steers at \$1 per bushel, and the corn silage was valued at \$3 per acre.

METHOD OF FEEDING AND HANDLING THE CATTLE.

The same system was followed as in 1913-14, all the feeds being mixed before feeding and the steers brought gradually to a full feed.

The initial and final weights were obtained from weighings made on three consecutive days, and weights were taken every 28 days during the progress of the experiment.

QUANTITY OF FEED CONSUMED AND AVERAGE DAILY RATIONS.

The average total quantities of feeds consumed by each steer in the various lots, and the average daily rations per head by 28-day periods, also for the total feeding period, are summarized in Table 22.

TABLE 22.—*Total and average daily rations, Oct. 21, 1914, to Jan. 24, 1915, 96 days.*

Lot	Number No. of steers.	Days fed.	Ration.	Total feed con- sumed per steer.	Average daily ration by periods.				Average daily ration for entire period.
					First period, 28 days.	Second period, 28 days.	Third period, 28 days.	Fourth period, 12 days.	
				<i>Pounds.</i>	<i>Pounds.</i>	<i>Pounds.</i>	<i>Pounds.</i>	<i>Pounds.</i>	<i>Pounds.</i>
1	10	96	Cottonseed meal.....	527	3.38	6.00	6.44	6.82	5.49 ¹
			Cottonseed hulls.....	2,308	21.84	25.00	25.00	25.00	24.04
			Ear corn.....	500	3.38	6.00	6.00	6.00	5.21
2	10	96	Cottonseed meal.....	711	5.17	8.00	8.64	8.68	7.41
			Cottonseed hulls.....	2,308	21.84	25.00	25.00	25.00	24.04
3	21	96	Cottonseed meal.....	711	5.17	8.00	8.64	8.68	7.41
			Corn silage.....	3,875	38.45	45.00	45.00	10.91	40.36
			Cottonseed hulls ¹					14.09	
4	26	111	Cottonseed meal.....	694	4.61	6.43	7.00	7.00	6.25
			Cottonseed hulls.....	2,212	18.66	21.07	20.00	20.00	19.92

¹ Cottonseed hulls were fed only the last 12 days of the feeding period.² Lot 4 was fed 111 days, or 27 days during the fourth period.

Each steer in Lot 1 ate 3.38 pounds each of cottonseed meal and ear corn and 21.84 pounds of cottonseed hulls daily during the first 28 days. These amounts were increased until in the last period of 12 days each steer consumed daily an average of 6.82 pounds of cottonseed meal, 6 pounds of ear corn, and 25 pounds of cottonseed hulls. The average daily ration per head for the entire 96 days was 5.49 pounds of cottonseed meal, 5.21 pounds of ear corn, and 24.04 pounds of cottonseed hulls.

The average daily ration per head of the steers in Lot 2 was 5.17 pounds of cottonseed meal and 21.84 pounds of cottonseed hulls for the first 28-day period. During the last 12 days each steer ate on the average 8.68 pounds of cottonseed meal and 25 pounds of cottonseed



FIG. 8.—Steers finished on cottonseed meal and corn silage (Lot 3, winter of 1914-15).

hulls per day. The average daily ration per head for the 96-day fattening period was 7.41 pounds of cottonseed meal and 24.04 pounds of cottonseed hulls.

The 21 steers in Lot 3 consumed an average daily ration per head of 5.17 pounds of cottonseed meal and 38.45 pounds of corn silage during the first 28 days. The quantities were increased to 8.64 pounds of cottonseed meal and 45 pounds of silage during the third period. The supply of silage ran short, so the average daily allowance was decreased to 10.91 pounds per head during the last 12 days, and 14.09 pounds of cottonseed hulls per head were substituted, while the cottonseed meal averaged 8.68 pounds per head. The average daily ration per head for the 96 days was 7.41 pounds of cottonseed meal and 40.36 pounds of corn silage.

Each of the 26 steers of Lot 4 was fed an average of 4.61 pounds of cottonseed meal and 18.66 pounds of cottonseed hulls per day during the first 28-day period. These amounts were increased to 7 pounds of cottonseed meal and 20 pounds of cottonseed hulls for the fourth period of 27 days. The average daily ration per head for the entire period of 111 days was 6.25 pounds of cottonseed meal and 19.92 pounds of cottonseed hulls.

Table 23 gives the average initial and final weights per head, the total gains, and the average daily gain per steer.

TABLE 23.—*Total and daily gains, 1914-15.*

Lot No.	Number of steers.	Days fed.	Ration.	Average initial weight per steer.	Average final weight per steer.	Average total gain per steer.	Average daily gain per steer.
1	10	96	Cottonseed meal, ear corn, and cottonseed hulls.....	<i>Pounds.</i> 941	<i>Pounds.</i> 1,096	<i>Pounds.</i> 155	<i>Pounds.</i> 1.61
2	10	96	Cottonseed meal and cottonseed hulls.....	967	1,103	136	1.42
3	21	96	Cottonseed meal and corn silage...	911	1,110	199	2.07
4	26	111	Cottonseed meal and cottonseed hulls.....	736	893	157	1.43

It will be seen that the average total gain per head for the steers in Lots 1 and 2 was 155 pounds and 136 pounds, respectively, which was equivalent to 1.61 pounds and 1.42 pounds per head daily. Comparing the results with those of the 1913-14 tests, it is seen that the addition of corn to the ration produced larger gains in both tests.

The steers in Lot 3 made an average daily gain per head of 2.07 pounds, or a total gain of 199 pounds for the 96 days, which is the best showing of any of the cattle. This shows rather forcibly the great value of corn silage in a fattening ration for steers, and, as will be seen later, these gains were the most economical.

The smaller steers of Lot 4, which were fed the same ration as those in Lot 2, made practically the same average daily gains, but over a longer period, gaining 157 pounds per head in the 111 days.

QUANTITIES AND COST OF FEEDS TO PRODUCE 100 POUNDS GAIN.

Table 24 shows the amount of feed that was required to produce 100 pounds of gain on the steers of the four lots, and the cost of this feed in each case.

TABLE 24.—Quantity and cost¹ of feeds required to produce 100 pounds of gain, 1914-15.

Lot No.	Number of steers.	Days fed.	Ration.	Quantity of feed required for 100 pounds gain.	Cost of feed for 100 pounds gain.
1	10	96	Cottonseed meal.....	340	12.96
			Ear corn.....	322	
			Cottonseed hulls.....	1,489	
2	10	96	Cottonseed meal.....	523	11.21
			Cottonseed hulls.....	1,687	
3	21	96	Cottonseed meal.....	357	
			Corn silage.....	2,055	7.60
4	26	111	Cottonseed meal.....	442	
			Cottonseed hulls.....	1,409	

¹ Prices of feed used:

Cottonseed meal.....	\$25.00 per ton.
Cottonseed hulls.....	5.50 per ton.
Corn silage.....	3.00 per ton.
Ear corn.....	1.00 per bushel.

This table reveals some interesting figures on the efficiency of the feeds used. Comparing Lots 1 and 2 it can be seen that the 322 pounds of corn fed to Lot 1 produced as much gain as 183 pounds of cottonseed meal and 198 pounds of cottonseed hulls. As the cost of these gains are shown in the last column to be \$12.96 and \$11.21 for Lots 1 and 2, respectively, it is evident that it would have been more economical to omit the corn.

The cattle in Lot 3 required only 357 pounds of cottonseed meal and 2,055 pounds of corn silage, costing \$7.60 to produce 100 pounds of gain. The efficiency of this ration and its low cost are the most striking facts illustrated in the table.

The smaller steers of Lot 4 made larger gains on the cottonseed meal and cottonseed hull rations than did the steers in Lot 2. This accounts for the smaller quantities of feed, and consequently smaller cost to produce 100 pounds of gain.

It will be noticed that the gains on all the cattle were produced much cheaper than in 1913-14. This was due chiefly to the lower cost of the cottonseed meal and cottonseed hulls for 1914-15, and the fact that expensive hay was not used in the rations.

SHIPPING AND SLAUGHTER DATA.

Table 25 shows the average final farm weight per head, the market weight, the shrinkage in transit, the average weights of carcasses, and the dressing percentages.

TABLE 25.—*Shipping and slaughter data, 1913-14.*¹

Lot No.	Number of steers.	Days fed.	Ration.	Average final farm weight per steer, Jan. 25.	Average market weight per steer at Richmond, Jan. 30.	Average shrinkage per steer in transit.	Per centage of shrinkage.	Average weight of carcass at New York, Feb. 1.	Per centage dressed by farm weight.	Per centage dressed by market weight.
1	10	96	Cottonseed meal, ear corn, and cottonseed hulls.....	<i>Pounds.</i> 1,096	<i>Pounds.</i> 1,042	<i>Pounds.</i> 54	<i>Per ct.</i> 4.92	<i>Pounds.</i> 586	<i>Per ct.</i> 53.43	<i>Per ct.</i> 56.23
2	10	96	Cottonseed meal and cottonseed hulls.....	1,103	1,055	48	4.35	597	54.17	56.61
3	21	96	Cottonseed meal and corn silage.....	1,110	1,057	53	4.77	603	54.32	57.05

¹ The steers in Lots 1, 2, and 3 were shipped to Richmond, Va., and after they had taken a fill were then sold to New York buyers; no live weights were secured at the New York market. Lot 4 was sold to local butchers, but the slaughter data are not available, as the steers were not marketed at the same time.

The steers were driven 15 miles to Clyde, N. C., and held till the following morning, January 26, when they were watered and fed and then loaded on the cars. They arrived in Richmond, Va., on the night of January 28. The shrinkage was 54, 48, and 53 pounds per head for Lots 1, 2, and 3, respectively, which shows very little difference for the various lots. The steers were sold to buyers in Richmond on January 30 and shipped to New York, where they were slaughtered on February 1. The slaughter data are calculated on the market weights taken in Richmond, as no weights were secured before killing at New York. The cattle of Lot 1 dressed 56.23 per cent; Lot 2, 56.61 per cent; and Lot 3, 57.05 per cent. This indicates that the ration of cottonseed meal and corn silage will produce as desirable carcasses as the ones fed to the other steers. No differences were assigned by the packers to the carcasses from the different lots. The cattle in Lot 4 were sold locally, and the slaughter data are not available.

FINANCIAL STATEMENT.

The financial statement of the feeding and marketing of the four lots of steers is given in Table 26.

TABLE 26.—*Financial statement, 1914-15.*

Lot 1, 10 steers, fattened on cottonseed meal, ear corn, and cottonseed hulls:

To 10 steers, 9,410 pounds at \$6.75 per cwt.....	\$635.17
To 5,270 pounds cottonseed meal at \$25 per ton.....	65.87
To 23,085 pounds cottonseed hulls at \$5.50 per ton.....	63.48
To 5,000 pounds ear corn at \$1 per bushel.....	71.43
Freight, Clyde, N. C., to Richmond.....	25.60
Feed at Spencer, N. C.....	2.00

Lot 1—Continued.

Feed at Richmond, Va.....	\$4. 15
Commission charges	10. 00
Total expenditures	877. 70
By sale of 10 steers, 10,960 pounds at \$7.75.....	849. 40
By value of 40 tons of manure at \$2 per ton.....	80. 00
Total receipts.....	929. 40
Total profit including manure.....	51. 70
Total loss not including manure.....	28. 30
Average profit per steer including manure.....	5. 17
Average loss per steer not including manure.....	2. 83

Lot 2, 10 steers, fattened on cottonseed meal and cottonseed hulls:

To 10 steers, 9,673 pounds at \$6.75 per cwt.....	652. 93
To 7,115 pounds cottonseed meal at \$25 per ton.....	81. 82
To 23,085 pounds cottonseed hulls at \$5.50 per ton.....	63. 48
Freight to Richmond from Clyde, N. C.....	25. 60
Feed at Spencer, N. C.....	2. 00
Feed at Richmond, Va.....	4. 15
Commission charges.....	10. 00
Total expenditures	839. 98
By sale of 10 steers, 11,030 pounds at \$7.75.....	854. 82
By value of 40 tons of manure at \$2 per ton.....	80. 00
Total receipts	934. 82
Total profit including manure.....	94. 84
Total profit not including manure.....	14. 84
Average profit per head including manure.....	9. 48
Average profit per head not including manure.....	1. 48

Lot 3, 21 steers, fattened on cottonseed meal and corn silage:

To 21 steers, 19,131 pounds at \$6.75 per cwt.....	1,291. 34
To 14,942 pounds cottonseed meal at \$25 per ton.....	186. 77
To 3,255 pounds cottonseed hulls at \$5.50 per ton.....	8. 95
To 81,375 pounds corn silage at \$3 per ton.....	122. 06
Freight, Clyde, N. C., to Richmond.....	51. 81
Feed at Spencer, N. C.....	4. 00
Feed at Richmond, Va.....	8. 75
Commission charges.....	21. 00
Total expenditures.....	1,694. 68
By sale of 21 steers, 23,310 pounds at \$7.75 per cwt.....	1,806. 53
By value of 84 tons of manure at \$2 per ton.....	168. 00
Total receipts	1,974. 53
Total profit including manure.....	279. 85
Total profit not including manure.....	111. 85
Average profit per head including manure.....	13. 33
Average profit per head not including manure.....	5. 33

Lot 4, 26 steers, fattened on cottonseed meal and cottonseed hulls:

To 26 steers, 19,130 pounds at \$6 per cwt-----	\$1, 147. 80
To 18,054 pounds cottonseed meal at \$25 per ton-----	225. 67
To 57,525 pounds cottonseed hulls at \$5.50 per ton-----	158. 19
Total expenditures -----	1, 531. 66
By sale of 26 steers, 23,230 pounds at \$7 per cwt-----	1, 626. 10
By value of 104 tons of manure at \$2 per ton-----	208. 00
Total receipts -----	1, 843. 10
Total profit including manure-----	302. 44
Total profit not including manure-----	94. 44
Average profit per steer including manure-----	11. 63
Average profit per steer not including manure-----	3. 63

When the cattle are credited with \$2 per ton for the manure produced, the steers in Lot 1 returned a profit of \$5.17 per head; those in Lot 2, 9.48 per head; Lot 3, \$13.33 per head; and Lot 4, \$11.63 per head. It will be seen that the steers in the first three lots cost the same per hundredweight and were sold for the same price per hundredweight. This allows direct comparison of the profits shown to the gains made and the cost of same.

The silage-fed steers of Lot 3 made the largest and cheapest gains and returned the largest profit. Those in Lot 1 made the next largest gains, but these gains cost more than on the cattle in Lot 2, so the profit on them was the smallest of the three.

Although the steers of Lot 4 made gains at the same rate as those of Lot 2 and were fed the same ration, their gains were made more cheaply, as shown in Table 24. They also returned a larger profit, even though they sold for 75 cents less per hundredweight.

SUMMARY STATEMENTS OF THE WINTER FATTENING TESTS.

WORK OF 1913-14.

1. The cattle used in this test were all native grade cattle, averaging 2 years of age.

2. The 24 steers were divided into two lots of 12 each and fed as follows:

Lot 1. Cottonseed meal, cottonseed hulls, corn stover, and hay.

Lot 2. Cottonseed meal, ear corn, cottonseed hulls, corn stover, and hay.

3. At the beginning of the test the steers in Lot 1 had an average weight of 819 pounds, and after 113 days on feed weighed on the average 973 pounds, showing a gain of 154 pounds per head, or an average daily gain per steer of 1.36 pounds.

The average initial weight of the steers in Lot 2 was 823 pounds and the final weight 983 pounds, which shows a gain of 160 pounds per head, equal to 1.42 pounds per head daily.

4. The cost of producing 100 pounds gain in Lot 1 was \$13.32; and in Lot 2, \$13.92.

5. The cattle as feeders cost \$5.50 per hundredweight in the fall. A margin of \$2.10 per hundredweight was realized when they were sold on the Baltimore market the following spring at \$7.60 per hundredweight for both lots.

6. The average profit per steer, including the value of the manure produced, was \$6.33 and \$5.44 for Lots 1 and 2, respectively. When the manure was not included there was a loss of \$1.67 per head in Lot 1 and \$2.56 per head in Lot 2.

WORK OF 1914-15.

1. The cattle used in Lots 1, 2, and 3 were good grade native 2 and 3 year old steers. Those composing Lot 4 were native grades averaging a little short of 2 years old and were classed as plain steers.

2. The steers were divided into four lots and fed as follows:

Lot 1, 10 steers, fed cottonseed meal, ear corn, and cottonseed hulls.

Lot 2, 10 steers, fed cottonseed meal and cottonseed hulls.

Lot 3, 21 steers, fed cottonseed meal and corn silage.

Lot 4, 26 steers, fed cottonseed meal and cottonseed hulls.

3. At the beginning of the experiment the average weights per head were: Lot 1, 941 pounds; Lot 2, 967 pounds; Lot 3, 911 pounds; and Lot 4, 736 pounds. After feeding 96 days the final weights for the steers average 1,096 pounds, 1,103 pounds and 1,110 pounds, respectively, for Lots 1, 2, and 3. These steers in Lot 4 were fed 111 days and weighed 893 pounds per head at the conclusion of the experiment. Thus the total gains per head were 155 pounds for Lot 1, 135 pounds for Lot 2, 199 pounds for Lot 3, and 157 pounds for Lot 4, making an average daily gain per head of 1.61 pounds, 1.42 pounds, 2.07 pounds, and 1.43 pounds for Lots 1, 2, 3, and 4, respectively.

4. It cost \$12.96 to produce 100 pounds of gain in Lot 1; in Lot 2, \$11.21; in Lot 3, \$7.60; and in Lot 4, \$9.40.

5. The cattle in Lots 1, 2, and 3 cost \$6.75 per hundredweight in the fall as feeders, and all sold for \$7.75 per hundredweight at Richmond the following spring. The steers in Lot 4 cost \$6 per hundredweight in the fall and sold for \$7 per hundredweight on the local market.

6. After crediting the steers with the manure produced, the average profit per head was as follows: Lot 1, \$5.17; Lot 2, \$9.48; Lot 3, \$13.33; and Lot 4, \$11.63. When the manure is excluded there was a loss on Lot 1 of \$2.83 per head, a profit on Lot 2 of \$1.48 per head, a profit on Lot 3 of \$5.33 per head; and a profit on Lot 4 of \$3.63 per head.

CONCLUSIONS FROM THE TWO YEARS' FATTENING EXPERIMENTS.

It must be understood that these conclusions should be interpreted by the reader to apply to feeding operations affected by conditions such as surrounded the tests just reported.

1. The use of hay valued at \$15 or more per ton for fattening steers increases the cost of gains very materially, as is shown by the first year's work. Cheaper roughages should be used if possible.

2. Cottonseed meal, even in moderate amounts, is very efficient in fattening steers, and the feeder usually can afford to buy it for this purpose if the other conditions are favorable.

3. The addition of ear corn to the ration increases the gains and the finish of steers, but unless it can be raised or purchased for considerably less per ton than cottonseed meal, its use in quantities is not advisable. If a farmer grows his own corn and is feeding steers, its use in the steers' ration as at least a part of the concentrate allowance is desirable if market price will permit.

4. Cottonseed meal and cottonseed hulls produce very satisfactory and economical gains when purchased at reasonable prices, such as was the case in these tests.

5. The remarkable efficiency and economy of corn silage in the ration of fattening steers is the most striking conclusion shown by the tests. Much more feeding could be done profitably in the region under discussion if more farmers would put their corn crops in silos and feed it in this form with cottonseed meal.

6. The heavy shrinkage in transit by the finished steers shows that the farmers in these sections must market their fat cattle under this disadvantage.

7. A study of the financial statements and costs of gains reveals many of the factors which affect the outcome of feeding operations. In calculating the profit or loss from feeding steers, the farmer should not overlook the value of the manure produced.

8. Farmers who can raise some surplus feed, especially roughages, should feel safe in feeding steers in the winter, provided they can buy feeders and cottonseed meal right and are not too far from a shipping point. If they can raise corn, it can be utilized with best results by feeding it as silage with or without other available roughages, cottonseed meal furnishing the chief concentrate to be fed with it. By so doing and using the manure on the land the productive capacity of the soil will be greatly increased.

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PROFESSIONAL PAPER

February 11, 1918

GREENHOUSE EXPERIMENTS ON THE RUST RESISTANCE OF OAT VARIETIES.¹

By JOHN H. PARKER, formerly Scientific Assistant, Office of Cereal Investigations.

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INTRODUCTION.

The rusts have long been recognized as one of the most serious limiting factors in the production of wheat and oats, both in the United States and in other countries. Considerable work has been done on the problem of controlling rust in wheat through resistant varieties and some results have been published, but very little specific information has been made available on the rust resistance of oat varieties in the United States.

The importance of the oat crop among the small grains in the United States is second only to that of wheat, and the problem of rust control is perhaps even more acute, for oats are more widely grown in localities favorable to rusts. For this reason a proper choice of varieties, based on accurate experimental tests, is a necessary factor in successful oat culture. The present paper presents the results obtained in greenhouse culture work with the crown rust of oats, *Puccinia lolii avenae* McAlpine (Pl. I, fig. 2, and Pl. II), and

¹The work here described was a part of the graduate studies of the writer during the college year 1915-16 at Cornell University and was a continuation of investigations conducted for several years while in the United States Department of Agriculture. The departments of plant breeding and plant pathology in the university provided every facility for the work, which was carried out under the supervision of Dr. H. H. Love, to whom thanks are due for many helpful suggestions.

the stem rust of oats, *Puccinia graminis avenae* Erikss. and Henn. (Pl. I, fig. 1, and Pl. III). These rusts are both rather common in the United States. The stem rust probably causes the greater loss in the Northern States and the crown rust in the Southern States.

THE CULTURE OF CEREAL RUSTS IN THE GREENHOUSE.

Obligate parasitism is a well-known characteristic of the rust fungi, and all attempts to grow them in artificial media have failed. They are easily cultured on the living host, however, and, as pointed out by Carleton (2),¹ it is possible to make many interesting studies by this method. Carleton described the method of inoculation used by him and gave suggestions concerning work with rusts.

Evans (4) has tested the rust resistance of oat varieties in the greenhouse and concludes that the Indian varieties are far more susceptible to the crown rust than to the stem rust.

Melhus (8) has described and illustrated the apparatus used and has given his methods in culturing parasitic fungi on the living host, including notes on culture work with the crown rust of oats.

Fromme (5) has published a comprehensive paper dealing with the culture of cereal rusts in the greenhouse, in which he briefly reviews the work of previous writers and describes in some detail his own methods, particularly the results obtained with the crown rust of oats.

Stakman (12) briefly describes culture methods used in his greenhouse studies of biologic forms of the cereal rusts and calls attention to the effects of temperature, humidity, and light on the incubation period. In a second paper (13) he has briefly described similar methods used in the additional study of cereal rusts on plants grown in the greenhouse.

Melchers (7) has suggested the use of galvanized-iron tubs with window-glass covers as moist chambers. He also advocates wetting the leaves to be inoculated by the "finger-rubbing" method instead of with an atomizer and keeping the pots bearing the rusted leaves in shallow pans of water, to avoid the necessity of overhead watering.

EXPERIMENTAL METHODS.

In the greenhouse experiments of the writer, methods similar to those above cited were employed. For the infection studies on seedling oat plants 4-inch pots were used, and 5-inch pots for the plants inoculated at heading time. Greenhouse potting soil of approximately the same make-up was used throughout the work. For the studies of plants at heading time four seeds of a variety were sown in each pot. When the plants were 6 to 8 inches high they were thinned to two in a pot, the number usually reserved for subsequent inoculation.

¹ The serial numbers in parentheses refer to "Literature cited," p. 16.



FIG. 1.—STEM RUST OF OATS: UREDINIA ON LEAVES, TELIA ON STEM.

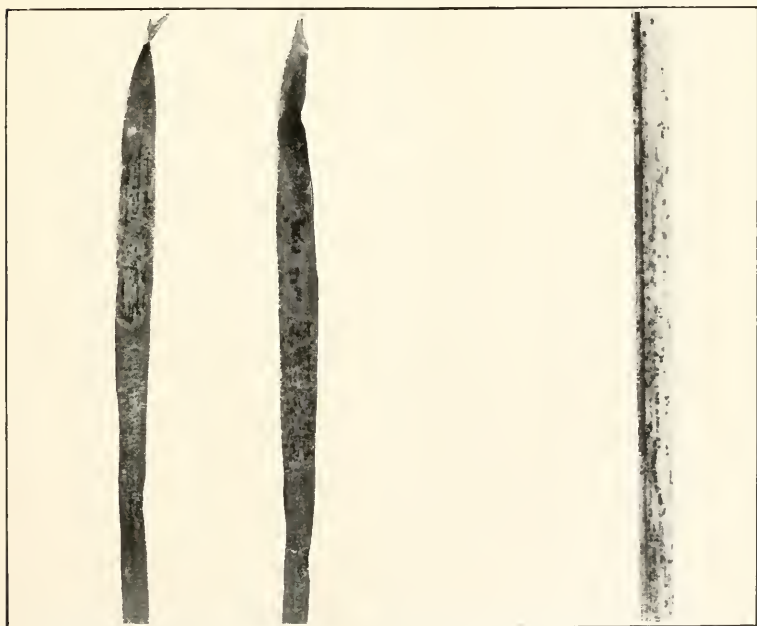


FIG. 2.—CROWN RUST OF OATS: UREDINIA ON LEAVES, TELIA ON STEM.

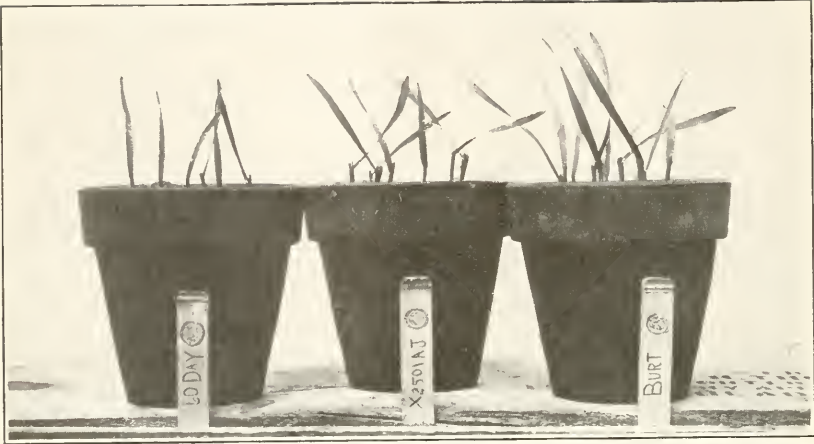


FIG. 1.—SEEDLING OAT PLANTS INOCULATED WITH CROWN RUST.



FIG. 2.—SEEDLING OAT PLANTS INOCULATED WITH STEM RUST.



SEEDLING LEAVES OF TWO STRAINS OF BURT OATS INFECTED WITH CROWN RUST, SHOWING ONLY A FEW SMALL PUSTULES BUT MANY FLECKS.

About 15 seeds per pot were sown for the seedling work, and the plants were thinned later, so that on an average about 8 plants per pot were inoculated. Plantings were made every few days from November, 1915, to April, 1916. Thus, there was always a series of plants coming on; as soon as one series had been inoculated another was about ready.

The cultures were kept in a cool greenhouse (night temperature, 50° to 55° F.; day temperature, 60° to 65° F.) and watered not less often than every alternate day. The inoculations on the seedling

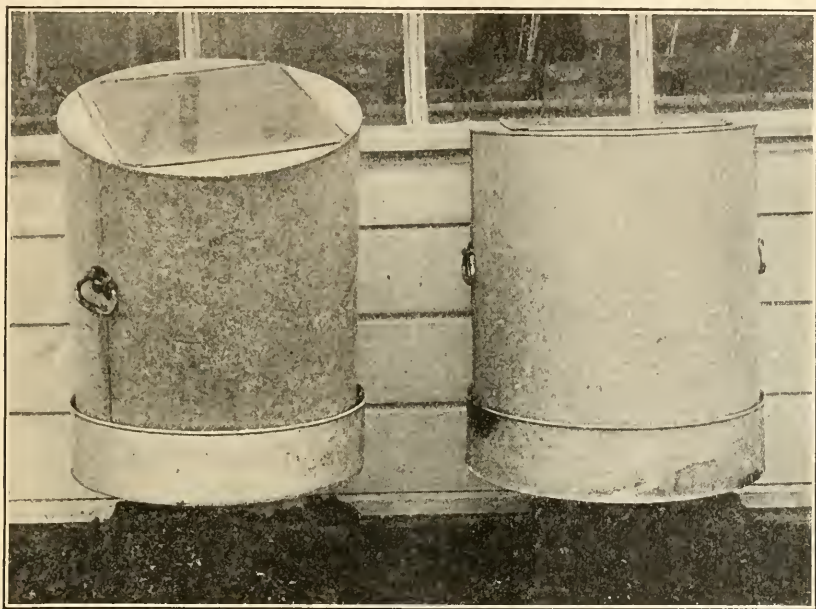


FIG. 1.—Glass-topped galvanized-iron moist chamber used for seedling plants.

plants were always made when the first (seedling) leaf was still vigorous and of a normal green color; that is, when the plants were only 3 to 5 inches high. This first leaf was always the only one inoculated. All others, with the "shoot," were kept trimmed off.

Spore material of both the oat rusts was obtained from the Minnesota Agricultural Experiment Station and increased for use as needed on stock cultures of the White Tartarian oat, the variety used as a check.

About ten varieties usually constituted the series treated on any one day, one set being inoculated with stem rust and the other with crown rust. No plants were left uninoculated, but one pot of White Tartarian serving as a check on the other varieties was always sown and inoculated with each series.

The inoculations were made by removing urediniospores with a flattened needle from a leaf bearing a heavy infection and placing

them on the previously moistened leaf to be inoculated. When all leaves in a pot were inoculated they were sprayed at once with an atomizer and placed in the moist chamber shown in figure 1, where they were allowed to remain 48 hours. These moist chambers, which will hold about forty 4-inch pots, cost less than \$10 for four. No trouble was experienced from the leaves burning or turning yellow, and almost 100 per cent of the inoculations were successful.

Inoculations of older plants were made in the order of heading of the varieties, beginning on April 10 and continuing to May 9, 1916. There were 12 to 18 plants in each series. The stem-rust

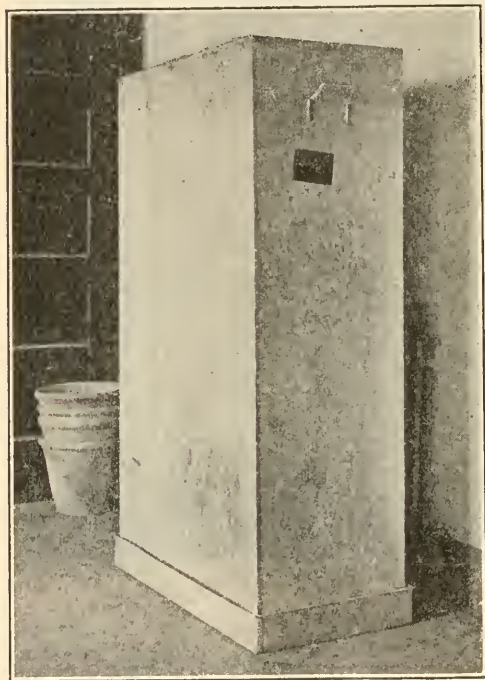


FIG. 2.—Glass-topped galvanvanized-iron moist chamber used for mature plants.

spores were always placed on the sheath inclosing the emerging panicle, while the inoculations with crown rust were made on the uppermost leaf blade. As with the seedlings, the inoculated plants were sprayed with an atomizer to insure the presence of a film of water and then kept in the moist chamber for two days. A special large glass-topped galvanvanized-iron moist chamber was made, holding eighteen 5-inch pots and allowing the tallest plants to remain upright (fig. 2).

The incubation period for the two rusts was approximately the same. Generally, though not always, the uredinia of the

stem rust appeared first. Cool temperatures seemed to lengthen the incubation period, for during November the house was cooler than during the succeeding months and the uredinia during this time were noticeably slower in appearing. Other factors, such as light, also may have affected the results.

Notes on the appearance of flecks usually were made in 7 to 9 days, and those on the formation of uredinia after a period of not longer than 12 days. Further notes usually were taken on the quantity and character of infection. No counts of uredinia were made; nor should too much emphasis be placed on whether or not all the leaves inoculated were equally infected, for it is obviously impossible to be cer-

tain that the same number of spores was applied in each case. The time of appearance, size of uredinia, and character of infection are deemed of greater importance.

The seedling plants were discarded as soon as final notes were obtained. Those in the series inoculated at the time of heading were allowed to mature in order to obtain herbarium specimens and seed for further work.

SOURCES OF MATERIAL.

The seed of all the varieties tested except Early Ripe¹ was obtained from the 1915 crop grown in rod rows in the rust nursery at Ames, Iowa. Most of these varieties were secured from Mr. C. W. Warburton, of the Office of Cereal Investigations, Bureau of Plant Industry; others were obtained from the Minnesota Agricultural Experiment Station. The forms listed under the Latin (specific) names (greenhouse Nos. 265 to 303) were obtained from Director Bubak, of the botanic garden at Tabor, Bohemia, through Prof. G. M. Reed, of the University of Missouri.

None of these varieties may properly be called a pure line, although some of these rows are traceable (several seasons back) to single plants. Others represent bulk material from rod rows, field plats, or commercial seed stocks. Some of the foreign material is in great need of more careful classification. Mixtures in the previous handling of both the domestic and foreign material sometimes have occurred, but it may be said safely that a majority of the varieties were true to name and for the most part pure, so that where eight or more seedlings were studied most of them really represented the true type of the variety under the name of which they were grown. In the trials on older plants, however, where only two individuals were studied, slight mixtures of the seed sample were more serious.²

EVIDENCES OF RUST RESISTANCE IN CEREALS.

Before proceeding to a detailed description and consideration of the observations made and conclusions drawn it will be well to refer to the observations of earlier workers on rust resistance in cereals.

Cobb (3) described certain wheat varieties which were resistant and mentioned the occurrence of dead areas of host tissue. Marryat (6) also observed these dead areas in immune varieties, and Biffen (1) mentions unopened pustules which shed no spores. Stakman (12) observed similar indications of real resistance on (*a*) seedling leaves of certain wheat varieties and on (*b*) leaves of a wheat susceptible to the stem rust of wheat but inoculated with the stem rust of oats. He states that the more resistant a form proved, the more pronounced was the tendency of the rust to kill small areas of the

¹ Seed of this variety was obtained from Dr. H. H. Love. It is very similar to Burt and perhaps identical with that variety. Evidence tends to show that the origin of the two varieties was the same.

² All such instances are indicated in Table I.

leaf and that the pustules developed in these areas were always very small. A further indication of immunity is said to be the fact that in the immune forms the incubation period is longer than in susceptible ones.

In a second paper (13) Stakman reports additional studies of the relation between *Puccinia graminis* and plants highly resistant to its attack. The occurrence of the same characteristic flecks or areas of killed tissue is again reported, but a new term, "hypersensitiveness," is used to describe the phenomenon.

Although no histologic studies have yet been made of the oat material, the external macroscopic evidence is in such close agreement with the observed conditions in wheat that there can be little doubt that a struggle between host and parasite of a very similar nature takes place within the tissues of the resistant oat varieties.

Concerning the indications or signs of resistance which were observed in the present study, it may be well to repeat that they are very similar to those in wheat. They are—

1. The prolonged incubation period.
2. The formation of flecks (yellow areas of dead host tissue).
3. The formation of larger blotches of dead tissue and, in extreme cases, the premature death of the whole seedling leaf.
4. Small uredinia, sometimes not completely or promptly rupturing the epidermis, and in *Puccinia graminis avenae* the formation of purple blotches adjacent to the uredinia.
5. The small number of uredinia (relatively unimportant).
6. The production of normal telia of the crown rust on seedling leaves of varieties which these other criteria indicate are resistant.

So far as known to the writer, the occurrence of telia on young seedling leaves of cereals grown in the greenhouse has not been recorded in literature. Melhus (8) states that in his cultures, which appear to have been on older plants, "teleutospores developed in two to three weeks."

It is certain that in the hundreds of seedlings described as very susceptible in the present experiments telia were not produced on a single one following a normal and abundant production of uredinia. The fungus on these leaves seems to have finished its life cycle under these conditions by producing the uredinia. After having remained a normal green color for some time after the formation of uredinia, the leaf finally dries up. That part of the life cycle so common to the rust fungus when on ripening grain plants in the field is not completed. On the other hand, quite early in the work it was observed that in a comparatively short time telia were present on the leaves of seedlings which gave other evidences of being resistant and on which no normal uredinia had been produced. The spores from these sori appear in every way normal, so far as determined by microscopic observation.

On the upper leaf blades of the plants inoculated at the time of heading, where one would normally expect the ultimate production of telia, the resistant plants seemed to produce them at a remarkably early stage. These early telia were produced, in all cases observed, only on leaves infected with the crown rust. It is the belief of the writer that such a hastening in the completion of the life cycle of the fungus is entirely comparable to the well-known instances in the seed plants of the influence of unfavorable conditions, such as drought, poor soil, and injury, in hastening the period of blooming and the maturing of seed.

The teliospores are to be considered necessarily as the final stage in the year's life cycle of the rust. These spores do not serve to spread the infection during the current season, but provide a means for the reproduction of the disease another season or when conditions are again favorable.

It may be argued that the ability which the fungus in these particular varieties possesses to produce this final spore form is the best possible indication of extreme susceptibility. Nevertheless, it is certainly true that if a variety is able to prevent the formation of the summer-spore stage of the rust, the spread of the disease will be checked in localities where only such varieties are grown.

This unusual occurrence of telia on seedling leaves is thought to be an additional evidence of resistance. It has been used sometimes in making the distinction between resistant and susceptible individual plants. Whether this interpretation is accepted or not, the presence of telia on seedling plants of some and their absence on other strains grown under identical conditions is very good evidence of real differences in the protoplasmic reaction of the two hosts, for the progress of the rust fungus following infection is quite different in the two instances. The same stimuli, whether they are chemical, enzymic, or osmotic, which cause the formation of flecks in some varieties and not in others may exercise a rather direct influence on the ability of the parasite to produce a particular spore form at any given time.

Norton (10) reports the abundant occurrence of aecia of the asparagus rust on plants which were resistant to the uredinial stage of the rust.

Smith (11), in studies of the water relations of asparagus rust, has found that "a very direct relation exists between atmospheric moisture and the prevalence of the several spore forms of the rust," and that "the teleuto stage may occur in asparagus beds little affected by the rust, and apparently not preceded by any trace of the other spore stages." He concludes that "the teleuto stage is then to be regarded as a provision for surviving any condition unfavorable to the fungus, whether of food supply, moisture, temperature, or resistance by the host, without regard to season."

Morgenthauer (9) conducted experiments to determine the effect of various influencing factors on the production of teliospores and found that "the time of appearance of the teleutospore stage is not dependent alone on the season of the year, but may be hastened or retarded by many other influences." He also states—

It is also true that the chemical constitution of the host may provide conditions either favorable or unfavorable for the nourishment of a particular parasite. There are cases known in which the same rust will produce uredospores copiously on one host and only sparingly on another. There may be in certain host plants substances toxic to the fungus, as tannin, which further influence the nourishment of the parasite, and with it its spore production.

This ability of various conditions to influence teleutospore production may also be regarded as a method of protection which the rusts have against influences which are unfavorable for the normal development of the fungus.

EXPERIMENTAL DATA.

Table I presents the results of all the varietal tests, including inoculations of both rusts made on seedling plants and on the plants at time of heading. The inoculations made were as follows:

Stem rust:	
Seedlings	1,256
Headed plants.....	260
Crown rust:	
Seedlings.....	1,480
Headed plants.....	260
Total	3,256

The varieties are arranged alphabetically by name in Table I, except that those bearing the Latin names under which they were received are placed in a separate list, as are also the varieties of red oats which are derivatives of *Avena sterilis*.

The greenhouse number (column 2), the classification list number (column 3), the Cereal Investigations number (column 4), the Seed and Plant Introduction number (column 5), and the Minnesota Agricultural Experiment Station number (column 6) are included in Table I in order that identification may be more certain. It is thus quite possible to compare the record of any variety in this list with statements made in literature regarding it or with field records.

In columns 7 to 10 of Table I the letter S indicates the undoubted and complete susceptibility of that variety under the conditions of the experiment. A question mark (?), S?, or R? indicates some doubt and the need of further tests, while R + S indicates that both resistant and susceptible plants were observed. The letter R has been used only where normal infection did not occur. In these instances the evidence seemed convincing that plants of the variety when tested in the manner here described prevented the formation of normal uredinia and may therefore be regarded as resistant. In a great

majority of cases all leaves or culms inoculated showed infection (normal uredinia) except in certain varieties where there were very evident signs of resistance and to which attention is directed in the footnotes to Table I.

TABLE I.—Summary of notes on the rust resistance of oat varieties tested in the greenhouse at Cornell University, Ithaca, N. Y., 1915-16.

[R.= resistant; S.= susceptible.]

Variety.	Identification numbers.					Crown rust.		Stem rust.		Remarks.
	Greenhouse.	Classification list.	Cereal Investigations.	S. P. I.	Minn. A. E. S.	Seedlings.	Plants at heading time.	Seedlings.	Plants at heading time.	
1	2	3	4	5	6	7	8	9	10	
Common (sativa) varieties:										
Abundance.....	7				272	S.	S.	S.	S.	
Alberta.....	94	1797				S.	S.	S.	¹ S.?	
American Banner.....	9				275	S.	S.	S.	S.	
Archangel.....	11				280	S.	S.	S.	S.	
Archangel×Early Gothland.....	23				305	S.	S.	S.	S.	
Banner.....	39				348	S.	S.	S.	S.	
Bicknell.....	51		206			S.	S.	S.	S.	
Big Four.....	42				354	S.	S.	S.	² R.?	
Black Anthony.....	102	1804				S.	S.	S.	S.	
Black Beauty.....	37				342	S.	S.	S.	S.	
Black Diamond.....	108	1814				S.	S.	S.	S.	
Black Tartarian.....	29					S.	S.	S.	S.	
Bumper Crop.....	91	1791				S.	S.	S.	S.	
Challenge.....	8				273	S.	S.	S.	S.	
Clydesdale.....	89	1729				S.	S.	S.	³ S.?	
Colorado No. 9.....	33				336	S.	S.	S.	S.	
Conqueror.....	96	1798				S.	S.	S.	S.	
Culberson selection.....	68		651			S.	S.	S.	S.	
Danish Giant.....	69		672			S.	S.	S.	S.	
Early Champion.....	4					S.	⁴ R.?	S.	⁵ R.+S.	Mixed seed.
Early Gothland.....	2				26	S.	⁶ S.?	S.	⁷ R.?	
English Wonder.....	104	1807				S.	S.	S.	S.	
Garton No. 5.....	83		739			S.	S.	S.	S.	
Garton No. 396.....	46				405	S.	S.	S.	S.	
Goldmine.....	103	1805				S.	S.	S.	S.	
Green Mountain.....	97	1799				S.	S.	S.	S.	
Green Russian.....	41				350	S.	S.	S.	⁸ R.+S.	Do.
Johnson.....	106	1808				S.	S.	S.	S.	
Junghans.....	98	1800				S.	S.	S.	S.	
King Oscar.....	36				341	S.	S.	S.	S.	
Ligowo.....	1				6	S.	S.	S.	S.	
Lincoln.....	34				340	S.	S.	S.	S.	
Pickett.....	88	1728				S.	S.	S.	S.	
Roosevelt.....	43				391	S.	S.	S.	S.	
Ruakura Rustproof ⁹	79		701			¹⁰ R. (+S.)	¹¹ R.+	¹² S.?	¹³ R. (+S.)	Do.

¹ Normal infection on one plant; on the other, only a few uredinia surrounded by purple blotches.

² Only a few abnormally small uredinia in 14 days after inoculation.

³ No uredinia in 10 days after inoculation, and finally only one on each culm, accompanied by purple color of host tissue.

⁴ Only a few tiny uredinia on each leaf.

⁵ Normal uredinia on one culm; only a few on the other.

⁶ Infection only fairly vigorous.

⁷ Unusually small uredinia first appeared 14 days after inoculation.

⁸ Normal infection on one culm; no uredinia on the other.

⁹ The results with this variety probably were more interesting and valuable than those from any other included in the test, for there were signs of resistance to both rusts at both stages of growth. This variety is of undoubted value as a source of the character of rust resistance, the more so because of its resemblance to yellow and white oat varieties of the *Avena sativa* group.

¹⁰ Six leaves severely rusted; on four only extremely small uredinia. In two pots of seedlings later inoculated no normal infection resulted.

¹¹ Flecks only; no uredinia. Within two weeks the small dark telia, characteristic of resistant varieties, were formed.

¹² Uredinia moderately abundant, somewhat small and surrounded by yellow flecks.

¹³ On one plant uredinia were abundant and of normal size. On the other plant they were small and tardy in breaking through the epidermis.

TABLE I.—Summary of notes on the rust resistance of oat varieties tested in the greenhouse at Cornell University, Ithaca, N. Y., 1915-16—Continued.

[R.= resistant; S.= susceptible.]

Variety.	Identification numbers.					Crown rust.		Stem rust.		Remarks.
	Greenhouse.	Classification list.	Cereal Investigations.	S. P. I.	Minn. A. E. S.	Seedlings.	Plants at heading time.	Seedlings.	Plants at heading time.	
1	2	3	4	5	6	7	8	9	10	
Common (sativa) varieties—Continued.										
Scottish Chief.....	92	1793				S.	S.	S.	S.	
Sensation.....	107	1811				S.	S.	S.	S.	
Shadeland Challenge.....	71		680			S.	S.	S.	S.	
Shadeland Climax.....	72		681			S.	S.	S.	S.	
Shireff.....	12				285	S.	S.	S.	S.	
Siberian.....	13				286	S.	S.	S.	S.	
Sixty-Day (Minn.).....	3				261	S.	S.	S.	S.	
Sixty-Day (parent).....						S.	S.	S.	S.	
Storm King.....	99	1802				S.	S.	S.	S.	14
Stube.....	87	1726				S.	S.	S.	S.	15
Swedish Select.....	6				271	S.	S.	S.	S.	
White Bonanza.....	44				403	S.	S.	S.	S.	
White Russian.....	18				301	S.	S.	S.	S.	
White Tartarian (check).....	5					S.	S.	S.	S.	
White Tartarian.....	101	1803				S.	S.	S.	S.	16
White Wonder.....	17				299	S.	S.	S.	S.	
Unnamed.....	64		605			S.	17 S.?	S.	S.	
Do.....	117		609	25259		S.	18 S.?	S.	S.	
Avena sativa (botanical races):										
Avena sativa.....	120			25356		S.	S.	S.	S.	
A. s. montana.....	265					S.	S.	S.	S.	
A. s. krausei.....	266					S.	S.	S.	S.	
A. s. aurea.....	267					S.	S.	S.	S.	
A. s. nigra.....	274					19 S.?	S.	S.	S.	
A. s. setosa.....	275					20 S.?	S.	S.	S.	
A. s. aristata.....	276					S.	S.	S.	S.	
A. s. mutica.....	277					S.	S.	S.	S.	
Do.....	278					S.	S.	S.	S.	
Do.....	279					S.	S.	S.	S.	
Do.....	280					S.	S.	S.	S.	
Do.....	281					S.	S.	S.	S.	
Do.....	282					S.	S.	S.	S.	
Do.....	283					S.	S.	S.	S.	
Do.....	284					S.	S.	S.	S.	
Do.....	285					S.	21 R.?	S.	S.	
Do.....	286					S.	S.	S.	S.	
Do.....	287					S.	S.	S.	S.	
Do.....	288					S.	S.	S.	S.	
Do.....	289					S.	S.	S.	S.	
Do.....	290					S.	S.	S.	S.	
A. s. praegravis.....	291					S.	S.	S.	S.	
Do.....	292					22 R.?	S.	S.	23 R.?	
Do.....	293					S.	S.	S.	S.	

¹⁴ Normal uredinia in the usual time on one plant; on the other culm subepidermal uredinia, at first small and surrounded by spots of purple color, but later rupturing the epidermis and attaining normal size.

¹⁵ Uredinia usually numerous, but small. Epidermis not always ruptured early; on some plants only flecks with tiny uredinia were formed.

¹⁶ Few uredinia, normal in size but accompanied by blotches of purple color, probably an anthocyanin, similar in appearance to those commonly present on sorghum and maize plants. These blotches were often observed adjacent to stem-rust uredinia and may indicate an unusual disturbance in the physiologic activities of the host cells, whether or not they are directly related to the question of resistance.

¹⁷ Light infection; uredinia few and of small size.

¹⁸ Light infection; uredinia tardy in appearing and never reaching normal size.

¹⁹ Normal infection on five leaves; light infection on two leaves.

²⁰ Normal infection on six leaves, medium on two, and only a light infection on two.

²¹ Only a very few tiny uredinia, formed 14 days after inoculation.

²² No uredinia on leaves of first seedlings inoculated; the leaves appeared dry and dead within a few days after inoculation. In the second series inoculated, only one leaf was severely infected. Eight showed medium infection, and on one no uredinia appeared.

²³ Normal infection on one plant; no indication of infection on the other.

TABLE I.—Summary of notes on the rust resistance of oat varieties tested in the greenhouse at Cornell University, Ithaca, N. Y., 1915-16—Continued.

[R.= resistant; S.= susceptible.]

Variety.	Identification numbers.					Crown rust.		Stem rust.		Remarks.
	Greenhouse.	Classification list.	Cereal Investigations.	S. P. I.	Minn. A. E. S.	Seedlings.	Plants at heading time.	Seedlings.	Plants at heading time.	
1	2	3	4	5	6	7	8	9	10	
<i>Avena sativa</i> (botanical races)—Continued.										
<i>A. s. trisperma</i>	291					²⁴ R.?	²⁵ R.?	S.	S.	Mixed seed.
<i>A. s. brunnea</i>	297					S.	S.	S.	S.	
<i>A. s. mutica</i>	298					S.	S.	S.	S.	
<i>A. s. praegravis</i>	299					S.	S.	S.	S.	
<i>A. s. mutica</i>	301					S.	S.	S.	S.	
Do.....	302					S.	S.	S.	S.	
Do.....	303					S.	²⁶ R.?	S.	S.	
Miscellaneous species of <i>Avena</i> :										
<i>Avena barbata</i>	119			25351		²⁷ S.?	²⁸ R. ? + S.	S.	S.	Do.
<i>A. brevis</i>	112					S.	S.	S.	S.	
Do.....	295					²⁹ S.?	³⁰ R.?	S.	S.	
<i>A. fatua</i>	109					S.	S.	S.	S.	
<i>A. f. glabrata</i>	111					S.	S.	S.	S.	
<i>A. ludoviciana</i>	114					S.	S.	S.	S.	
<i>A. nuda</i>	118			25351		S.	S.	S.	S.	Do.
Do.....	126			16894		S.	S.	S.	³¹ R.?	
<i>A. orientalis pugnax</i>	268					S.	S.	S.	S.	
<i>A. o. tristis</i>	269					S.	S.	S.	S.	
<i>A. o. tartarica</i>	270					S.	S.	S.	S.	
<i>A. o. mutica</i>	271					S.	S.	S.	³² R.?	
<i>A. o. flava</i>	272					S.	S.	S.	S.	Do.
<i>A. o. obtusata</i>	273					S.	³³ R.?	S.	S.	
<i>A. purpurea</i>	121			25357		S.	S.	S.	³⁴ R.?	
<i>Avena sterilis</i> and varieties:										
<i>Avena sterilis</i>	116		543	21751		S.	³⁵ S.?	S.	S.	
Do.....	296					S.	S.	S.	S.	
Algerian Red.....	47					S.	S.	S.	S.	
Appler.....	74		695			³⁶ R.?	R.	S.	S.	
Burt.....	48					³⁷ S.?	³⁸ R.	S.	S.	

²⁴ In the first series inoculated, small uredinia on two out of nine leaves, flecks only on seven. All leaves soon dry and dead. In the second series inoculated, heavy infection occurred on five and light infection on five.

²⁵ Flecks only 10 days after inoculation; later a few tiny uredinia, accompanied and surrounded by many flecks.

²⁶ No uredinia 10 days after inoculation; later a few tiny ones on each leaf, surrounded by flecked areas of host tissue.

²⁷ In the first series fairly heavy infections were obtained on all leaves inoculated, but uredinia were small. In the second series normal infection on two leaves, medium on eight, and light on two.

²⁸ Heavy infection on only one leaf; only a few tiny uredinia on the other two.

²⁹ In the first series of inoculations fairly vigorous infections were obtained on some of the leaves. On other leaves only a few small uredinia appeared, the leaf soon drying and turning brown. In a second series, normal infection occurred on all leaves inoculated.

³⁰ Flecks only 10 days after inoculation. A few small uredinia appeared later, accompanied by distinct flecks.

³¹ On one plant, uredinia nearly normal in size, but accompanied by purple blotches; no uredinia were produced on the other plant.

³² Uredinia few and small; infection not heavy.

³³ No evidence of infection in 10 days after inoculation; the few uredinia finally produced were small.

³⁴ Uredinia normal on one plant; on the other small and surrounded by purple blotches.

³⁵ Flecks only on one of the two leaves inoculated. The leaf soon dried up. A large number of normal uredinia appeared on the tip of the other leaf. On most of the leaf surface, however, there were very few uredinia but many flecks.

³⁶ Of the first series of 11 leaves inoculated 5 were heavily infected, while on 6 only flecks were evident. In the second series inoculated uredinia were produced on all leaves but were accompanied by many yellowish flecks, and larger blotches of dead host tissue surrounded each uredinium.

³⁷ In the first series of leaves inoculated 6 out of 10 leaves were rather heavily rusted, 1 showed light infection, and on 3 only flecks appeared. In the second series nearly normal infections were secured on all the 8 leaves inoculated. In the third series medium to good infection resulted on all 11 leaves inoculated. Many of the uredinia were of normal size, but surrounded by light yellowish green flecks.

³⁸ No uredinia. Rather indistinct light-green flecks were observed, indicative of the presence of rust hyphae.

TABLE I.—*Summary of notes on the rust resistance of oat varieties tested in the greenhouse at Cornell University, Ithaca, N. Y., 1915-16—Continued.*

[R.= resistant; S.= susceptible.]

Variety.	Identification numbers.					Crown rust.		Stem rust.		Remarks.
	Greenhouse.	Classification list.	Cereal Investigations.	S. P. I.	Minn. A. E. S.	Seedlings.	Plants at heading time.	Seedlings.	Plants at heading time.	
1	2	3	4	5	6	7	8	9	10	
<i>Avena sterilis</i> and varieties—Continued.										
Burt.....	76		696			39 R.?	40 R.	S.	S.	
Do.....	81		710			41 R.	42 R.?	S.	S.	
Early Ripe.....						3 R. (+ S)	43 R.	S.	S.	
Cook.....	77		697			45 R.?	46 R.	S.	S.	
Fulghum.....	73		694			47 S.?	48 R.	S.	S.	
Golden Rustproof.....	61		509			49 S.?	50 R.?	S.	S.	
Do.....	93	1796				S.	S.	S.	S.	
Italian Rustproof.....	54		388			S.	S.	S.	61 R.?	
Do.....	57		397			S.	S.	S.	S.	
Italian Rustproof selection.	58		409-4			52 R.	53 R.	S.	S.	
Red Rustproof.....	24				309	S.	S.	S.	S.	
Red Rustproof selection	52		261-7			54 S.?	S.	S.	55 R. + S.	
Do.....	62		518-15			56 R.?	57 R.	S.	S.	
Do.....	78		700			58 S.?	S.	S.	S.	
Siberian Red.....	59		487			S.	S.	S.	59 R.?	
Turkish Rustproof selection.	53		356-19			S.	S.	S.	S.	
Do.....	67		627			60 R.?	61 R.	S.	S.	

³⁹ Three series of inoculations were made. In each some leaves were rather heavily rusted, others lightly, and on some no uredinia (only flecks) were formed. Tella were freely produced on leaves where no normal uredinia had previously ruptured the epidermis.

⁴⁰ Normal uredinia on one leaf; flecks only on the other.

⁴¹ In the three series of inoculations made no leaf was heavily rusted. Only a few had even a slight infection, while most of them very quickly showed large reddish brown blotches of dead tissue and smaller yellowish green flecks and no uredinia (see Pl. III).

⁴² Normal infection at the base of each leaf, the upper portion heavily flecked and soon turning brown in color, with no normal uredinia.

⁴³ In the seven series inoculated, there were both susceptible and resistant plants, the former with many normal uredinia, the latter with few and small uredinia or flecks only. On many leaves, large blotches of host tissue were killed soon after inoculation. On some of these, tella were later developed.

⁴⁴ Of five leaves inoculated, on only one were normal uredinia produced and these only at the base. On one leaf a few tiny uredinia were formed, and on three flecks only appeared.

⁴⁵ In the first series of 6 leaves inoculated, a few light-green flecks furnished the only evidences of infection. In two later series of 6 and 10 leaves inoculated, normal infections occurred on 8 of the 16, while the other 8 had only small uredinia or flecks.

⁴⁶ No uredinia appeared in three weeks after inoculation; then only tiny ones on one leaf. Distinct flecks were evident.

⁴⁷ Of 9 leaves in the first series inoculated, 1 was heavily rusted, 6 medium, and on 2 only flecks appeared. Of 14 leaves in a second series, fairly normal infection occurred on all, though some uredinia were rather small. No sharp indications of resistance.

⁴⁸ Two leaves inoculated; on neither were any normal uredinia produced. Uredinia small and accompanied by flecks.

⁴⁹ In the first series of 8 leaves, normal infection occurred on 5, light on 2, flecks only on 1. In the second series of 9 leaves, 4 were heavily rusted and 5 lightly.

⁵⁰ No uredinia in 11 days after inoculation, then only 1 or 2 small ones on each leaf. There were also blotches of dead host tissue.

⁵¹ No uredinia normal in size or vigor; after 21 days they were still small.

⁵² Of 6 inoculated leaves in the first series, normal infection was produced on 3 and very small uredinia and flecks on 3. No normal infection occurred on 9 leaves inoculated in the second series. There were only a few tiny uredinia with many flecks.

⁵³ No signs of infection except dead leaf tips.

⁵⁴ In the first series of 9 leaves inoculated, normal infection was secured on 6, while only flecks appeared on 3 in the time characteristic for uredinia. Tella were formed later. In the second series, the 2 leaves inoculated were rusted heavily.

⁵⁵ Normal (very heavy) infection on one culm; only a very few small uredinia on the other.

⁵⁶ No evidences of infection on the leaves of the first series inoculated. Only a few tiny uredinia were formed on the 9 leaves in the second series inoculated.

⁵⁷ Only a few very small uredinia; many flecks.

⁵⁸ Of 10 leaves in the first series inoculated, 6 were heavily rusted and a light infection on 4. Of 11 leaves in the second series, 6 were heavily rusted, on 4 only a few very small uredinia developed, and on 1 only flecks appeared in the time usual for uredinia formation. An abundance of tella later occurred.

⁵⁹ No uredinia of normal size and vigor; only a few tiny ones on each leaf.

⁶⁰ Of the first series of five leaves inoculated, one was very heavily rusted, three had only a light infection, and on one only flecks were produced. All leaves of the second series inoculated were rather heavily rusted, but numerous flecks were observed, also indicating some degree of resistance.

⁶¹ Infection not heavy; uredinia on each leaf few and small.

DISCUSSION OF RESULTS.

The notes in Table I on the varieties which showed resistance to one or both rusts indicate that rust resistance is very specific and that a particular variety may be entirely susceptible to one rust and somewhat resistant to the attacks of another.¹

Of the 122 strains tested, 80 unquestionably were susceptible to both rusts in both stages of growth. This does not imply that these varieties are not of great commercial value in other respects and is not sufficient reason for discarding them from cultivation, for at present there are no suitable varieties to substitute for the best of them. It probably does remove them, however, from the list which is to afford promise of rust-resistant varieties. Heavy infections were obtained on practically all of these, and at least some normal uredinia were formed on all. While such greenhouse tests do not represent field conditions accurately, the optimum conditions for infection provided should make the evidences of resistance which appeared in some varieties all the more valuable. Some of these varieties may show some resistance under field conditions and some of them have properly been recommended as rust-escaping because of their early-ripening habit, as, for instance, the Sixty-Day and Kherson varieties.

In 80 out of the 122 cases the results at two distinct periods in the life of the host plant have led to identical conclusions as to the susceptibility of the variety. In some of the resistant varieties, also, both seedlings and mature plants gave the same evidences of resistance, though the results are not always in agreement. These susceptible varieties need not be discussed in further detail, but the list includes the following commonly grown sorts: American Banner, Big Four, Ligowo, Lincoln, Siberian, Sixty-Day, Swedish Select, and White Russian. In this list are included also most of the botanical species represented and nearly all of the recently introduced foreign varieties.

In the *Avena sterilis* group also, where most of the resistance to crown rust is found, several strains are very susceptible to the crown rust, as, for instance, Greenhouse No. 296, Red Algerian, and one strain each of Golden Rustproof, Italian Rustproof, Red Rustproof, and Turkish Rustproof.

Not all varieties of the *Avena sterilis* group show perceptible resistance to either rust, and great care should be exercised in recommending to farmers these or other varieties as rust resistant. Still greater care is necessary in choosing a strain to use as a parent

¹ The studies of these varieties indicate the necessity for selecting and working from individual plants, for certainly within the same variety, and even within a line supposed to be pure for other characters, differences of a major degree in rust resistance exist.

variety with the purpose of obtaining a resistant variety through hybridization.

None of the seedlings of the 23 varieties belonging to the *Avena sterilis* group showed any resistance to the stem rust, and in only three of the varieties did the plants inoculated at heading time give any evidence of resistance to this rust. It is entirely safe to conclude that all of these varieties are quite susceptible to stem rust, and the *Avena sterilis* group probably will offer little in the way of resistance to stem rust that is of value to the plant breeder.

Of these 23 varieties 16 show some degree of resistance to crown rust. Certain strains were strikingly resistant in both the seedling stage and at heading time, and from the clear-cut evidences of resistance there can be no doubt of the presence of resistance to crown rust in varieties of this group.

These varieties which are actually resistant to crown rust, if found to be high in yield, should replace some of the "rustproof" types now being grown in the Southern States. They may be of use also in the breeding of rust-resistant varieties for culture in other sections of the country.

Table I shows that there are many more cases of resistance to the crown rust than to the stem rust. This is especially true of the work on seedlings, where none of the varieties tested except White Tartarian and Ruakura Rustproof showed any resistance to stem rust.

In the studies of both rusts, more apparent cases of resistance are recorded from the inoculations made on the plants at the time of heading. This may be due to the fact that plants are more susceptible as seedlings than when more mature. It is more likely, however, that some of the failures to get normal or heavy infection were due to the fact that it was more difficult to wet thoroughly, and hence inoculate heavily, the upper leaf blades and sheaths than the young seedling leaves.

The use of the word "immune" is avoided, for in the forms studied none were observed in which very distinct evidences of infection did not appear. The words "resistant" and "resistance" are used only in a relative sense and refer to that condition in which normal urediniospore production by the fungus was either prevented or seriously interfered with. As Stakman (13) has pointed out, the quality which is called resistance may actually be, in the extreme sense, susceptibility or hypersensitiveness. It amounts to "commercial resistance," using that expression to describe a variety which will suffer less severe damage in the field than some others.

SUMMARY AND CONCLUSIONS.

- (1) Two distinct rusts of oats are common in the United States:
(a) Stem rust, *Puccinia graminis avenae* Erikss. and Henn., and (b)

crown or leaf rust, *Puccinia lolii avenae* McAlpine. The stem rust is more common in the North, while the crown rust, though practically always present, seems to be most abundant and serious in the South.

(2) Greenhouse studies are of value in determining varietal resistance under optimum conditions for infection. These studies, however, should always be supplemented by rust nursery and field trials.

(3) Plants of more than 120 strains of oats were inoculated at two different periods of growth (the seedling stage and the heading stage) and their reaction to both rusts determined.

(4) The inoculations made on these varieties were as follows: Stem rust.—Seedlings, 1,256; headed plants, 260. Crown rust.—Seedlings, 1,480; headed plants, 260. Total, 3,256.

(5) Of more than 120 strains tested, 80 were found to be entirely susceptible to both rusts at both stages of growth. Unquestionable resistance to stem rust was present in only two varieties, White Tartarian and Ruakura Rustproof. Several varieties of the red-oat group (*Avena sterilis*), including certain strains of Burt, Cook, Appler, Italian Rustproof, Red Rustproof, and Turkish Rustproof, are very resistant to the crown rust. Ruakura Rustproof and certain recently introduced species of *Avena* also gave indications of resistance to crown rust.

(6) Rust resistance is shown to be specific, for many of the varieties which are resistant to crown rust are thoroughly susceptible to the stem rust under identical conditions. The evidences of resistance described for wheat are shown to apply also to resistant oat varieties. In addition, the early production of telia on seedling leaves has been observed and is believed to be an indication of resistance.

(7) Further search must be made for varieties resistant to stem rust.

(8) Varieties of the *Avena sterilis* group which are really resistant to the crown rust, if found to be high in yield, should replace other "rustproof" varieties now being grown in the Southern States. None of the varieties of this group which have been tested will withstand the attacks of stem rust.

(9) A basis is now offered for making selections and crosses to produce improved oat varieties resistant to crown rust and suitable for culture in the several oat-growing areas of the United States.

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PROFESSIONAL PAPER

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STUDIES ON THE DIGESTIBILITY OF SOME NUT OILS.¹By A. D. HOLMES, *Specialist in Charge of Digestion Experiments, Office of Home Economics.*

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INTRODUCTION.

This paper records the results of a study of the digestibility of almond, black-walnut, Brazil-nut, butternut, English-walnut, hickory-nut, and pecan oils.

Previous papers² of this series have reported the digestibility of lard, beef fat, mutton fat (kidney fats), butter; cream, chicken, goose, fish, brisket, and egg-yolk fats; and cocoa butter, olive, cottonseed, peanut, coconut, and sesame oils. The results of the study of the digestibility of these fats indicate that they are well utilized by the human body and may be used in amounts exceeding those of the ordinary diet, without causing any laxative effects. In the experiments all of the fats were separated from the materials in which they naturally occur. Most of them are thus used in the ordinary diet, though with a few (egg fat and fish fat, for example) this is not the case. The present paper has to do with the digestibility of the oils obtained from some of the common nuts considered in comparison with the digestibility of the large number of animal and vegetable fats which are being considered in this series. While these oils can

¹ Prepared under the direction of C. F. Langworthy, Chief, Office of Home Economics.

² U. S. Dept. Agr. Buls. 310 (1915), 505 (1917), 507 (1917).

NOTE.—This bulletin is primarily of interest to students and investigators of food problems.

not be purchased in any considerable quantities and are little used in this country as such, very considerable quantities are consumed annually as a constituent of the nuts in which they occur.

Inasmuch as sufficient quantities of these nut oils could not be procured in the open market, a supply of good grade nuts of the varieties to be studied was procured and the oils were expressed under laboratory conditions with a hydraulic press having a capacity of 35 tons pressure on a 6-inch plunger. All of the oils were "cold pressed" and were of excellent quality, being in such good condition that no refining was necessary. They were allowed to stand some hours in order that any suspended matter might settle and then they were filtered through one thickness of ordinary filter paper. In all instances the oils were of good color, without odor, and possessed a bland flavor; in one or two instances more or less of the characteristic flavor of the nuts from which the oils were derived could be detected. Since they were used within a short time after they were expressed, little information was obtained in regard to the keeping quality of the oils.

The press cake remaining after the oils had been expressed from the nuts was quite palatable though not as "rich" as the nuts, and rather dry if eaten alone. The characteristic flavor of the nuts was retained by it and was in many cases intensified. Since the press cake was derived from a good grade of cleaned nuts it had considerable interest as a possible food material, especially in view of its high protein content. That obtained from several varieties of nuts was accordingly studied in this office from a dietetic standpoint, and various recipes for its use were developed. The value and possible uses of such press cake will be discussed in a later publication.

In the studies of the digestibility of the 16 animal or vegetable fats, reported in previous bulletins, an average of eight tests was made with each fat; in only one case were there less than five experiments. Because of the limited available supply of the oils considered in this paper only three or four tests could be made with the oils studied.

METHODS OF PROCEDURE.

The digestion experiments with the nut oils were conducted by the same methods as those with the animal and vegetable fats already reported, the object being to maintain identical experimental conditions for each fat studied and thus to make the values obtained for the digestibility of the different fats directly comparable with one another.

As in the earlier experiments, a blancmange, or cornstarch pudding, served as the medium for introducing the fat under consideration. The blancmange was prepared by the method outlined in a

previous paper¹ and in amounts sufficient to supply all the subjects for the entire experimental period. In order to mask the presence of the large quantity of fat and to secure a blancmange which would be of uniform color and flavor for all experiments, thus avoiding as far as possible any psychic effects, a caramel solution was added to the blancmange during its preparation.²

The accessory foods which the diet contained in addition to the blancmange and which were selected because they supplied a minimum of fat, were wheat biscuit, oranges, and sugar. In case the subjects so desired, they were permitted to take tea or coffee, without milk or cream, with their meals. All constituents of the diet except the tea or coffee were eaten cold.

The feces resulting from the diet under consideration were identified by means of charcoal taken in gelatin capsules with the first meal of the test period and with the first meal following the test period. The feces were collected in weighed glass containers and dried in an electric oven regulated to maintain a temperature of 95° C., pulverized and analyzed. The urine was not collected or analyzed, and no attempt was made to maintain a nitrogen equilibrium, since in this investigation attention was centered on the digestibility of the fats.

The customary three-day or nine-meal test period was judged to be of sufficient duration to permit of satisfactory analytical results and still not so long as to become monotonous. No record of the body weights of the subjects was kept, but the men were expected to submit a report of their physical condition during the interdiet periods as well as during the experimental periods. As they reported being in normal physical condition throughout the investigation their reports will not be referred to in detail.

SUBJECTS.

Men between 20 and 40 years of age, of normal health and appetite, served as subjects for this investigation. With one exception, they were all students and, while they were mainly engaged in mental activities, their exercise was enough to make their energy requirements considerably in excess of those persons with sedentary occupations. They had all had previous experience in such experimental work and fully appreciated the necessity for accuracy in carrying out the directions given, saving uneaten portions of food, collecting

¹ U. S. Dept. Agr. Bul. 310 (1915).

² Recently Plaisance and Mousch (*Jour. Home Econ.*, 9 (1917), No. 4, p. 167) have reported that when caramel is prepared by heating sugar at temperatures of 180° C. and 200° C. from 0.02 per cent to 0.09 per cent of furfural is formed. The authors further state that if the caramel is subsequently cooked in the presence of water the furfural is removed, which perhaps may explain the absence of any toxic effects resulting from the use of caramel in the preparation of the blancmange.

feces, etc. While there were no prescribed hours for eating, the subjects were informed that regularity was desired and they were requested to follow their normal daily routine as far as possible.

ALMOND OIL.

Commercial almond oil is obtained by subjecting the seeds of *Prunus amygdalus* to hydraulic pressure. Almond oil, of which considerable quantities appear in commerce, is principally used in the preparation of ointments, emulsions, and toilet soaps. It possesses, however, all the essentials characteristic of an edible oil, and hence the question of its value as human food is an interesting one. The literature shows no investigations of the digestibility of almond oil as such.

In a series of digestion experiments conducted to determine the relative digestibility of fruits and nuts Jaffa¹ studied the digestibility of almonds eaten in conjunction with bananas, apples, dates, olives, and oranges combined in different ways. The total fat of the diet was found to be 84 per cent digested. Inasmuch as 83 per cent, or approximately 97 grams of the 117 grams of fat eaten daily, was derived from the almonds, this value should very nearly represent the digestibility of almond oil when eaten as a constituent of almonds.

The almond oil studied in this investigation was prepared by expression from a supply of first quality sweet almond nuts purchased in the open market. The oil which was obtained had no marked flavor or odor and, judged by household tests, was a very satisfactory table oil. It was incorporated in the usual cornstarch blanc-mange and eaten by the four subjects who assisted in this study. The results of the four experiments are included in the following table:

Data of digestion experiments with almond oil in a simple mixed diet.

Experiment, subject, and diet.	Weight of foods.	Constituents of foods.				
		Water.	Protein.	Fat.	Carbo-hydrates.	Ash.
	<i>Grams.</i>	<i>Grams.</i>	<i>Grams.</i>	<i>Grams.</i>	<i>Grams.</i>	<i>Grams.</i>
Experiment No. 555, subject H. R. G.:						
Blanc-mange containing almond oil.....	1,463.0	672.0	27.4	170.9	580.0	12.7
Wheat biscuit.....	306.0	27.6	32.4	4.6	236.5	4.9
Fruit.....	458.0	398.0	3.7	0.9	53.1	2.3
Sugar.....	17.0				17.0	
Total food consumed.....	2,244.0	1,097.6	63.5	176.4	886.6	19.9
Feces.....	77.0		24.6	6.7	40.0	5.7
Amount utilized.....			38.9	169.7	846.6	14.2
Percent utilized.....			61.3	96.2	95.5	71.4

¹ U. S. Dept. Agr., Office Expt. Stas. Bul. 132 (1903).

Data of digestion experiments with almond oil in a simple mixed diet—Contd.

Experiment, subject, and diet.	Weight of foods.	Constituents of foods.				
		Water.	Protein.	Fat.	Carbo-hydrates.	Ash.
Experiment No. 556, subject A. J. H.:	<i>Grams.</i>	<i>Grams.</i>	<i>Grams.</i>	<i>Grams.</i>	<i>Grams.</i>	<i>Grams.</i>
Blancmange containing almond oil.....	1,671.0	767.5	31.2	195.2	662.6	14.5
Wheat biscuit.....	324.0	281.6	2.6	0.6	37.6	1.6
Fruit.....	42.0				42.0	
Sugar.....						
Total food consumed.....	2,037.0	1,049.1	33.8	195.8	742.2	16.1
Feces.....	85.0		27.1	26.9	21.4	9.6
Amount utilized.....			6.7	168.9	720.8	6.5
Per cent utilized.....			19.8	86.3	97.1	40.4
Experiment No. 557, subject P. K.:						
Blancmange containing almond oil.....	2,069.0	950.3	38.7	241.7	820.3	18.0
Wheat biscuit.....	320.0	28.8	33.9	4.8	247.4	5.1
Fruit.....	638.0	554.4	5.1	1.3	74.0	3.2
Sugar.....	67.0				67.0	
Total food consumed.....	3,091.0	1,533.5	77.7	247.8	1,208.7	26.3
Feces.....	89.0		28.4	13.7	38.7	8.2
Amount utilized.....			49.3	234.1	1,170.0	18.1
Per cent utilized.....			63.4	94.5	96.8	68.8
Experiment No. 558, subject C. J. W.:						
Blancmange containing almond oil.....	1,945.0	893.3	36.4	227.2	771.2	16.9
Wheat biscuit.....	287.0	25.8	30.4	4.3	221.9	4.6
Fruit.....	975.0	847.3	7.8	1.9	113.1	4.9
Sugar.....	29.0				29.0	
Total food consumed.....	3,236.0	1,766.4	74.6	233.4	1,135.2	26.4
Feces.....	102.0		32.8	10.7	50.2	8.3
Amount utilized.....			41.8	222.7	1,085.0	18.1
Per cent utilized.....			56.0	95.4	95.6	68.6
Average food consumed per subject per day....	884.3	453.9	20.8	71.1	331.1	7.4

Summary of digestion experiments with almond oil in a simple mixed diet.

Experiment No.	Subject.	Protein.	Fat.	Carbo-hydrates.	Ash.
		<i>Per cent.</i>	<i>Per cent.</i>	<i>Per cent.</i>	<i>Per cent.</i>
555.....	H. R. G.....	61.3	96.2	95.5	71.4
556.....	A. J. H.....	19.8	86.3	97.1	40.4
557.....	P. K.....	63.4	94.5	96.8	68.8
558.....	C. J. W.....	56.0	95.4	95.6	68.6
	Average.....	50.1	93.1	96.3	62.3

In the four experiments made with the almond oil an average of 21 grams of protein, 71 grams of fat (of which 70 grams was almond oil), and 331 grams of carbohydrates was eaten per man per day, and of these amounts 50.1 per cent of the protein, 93.1 per cent of the fat, and 96.3 per cent of the carbohydrates was digested. The value, 93.1 per cent obtained for the digestibility of fat, applies to the digestibility of the total fat of the diet and is increased to 97.1 when allowance is made for the undigested residue resulting from the basal ration and occurring in the ether extract of the feces.

The coefficient of digestibility of almond oil as determined by these experiments is, for all practical purposes, identical with the coefficient of digestibility, 97 per cent, reported in an earlier paper¹ of this series for the most widely used animal fats, butter, and lard.

BLACK-WALNUT OIL.

Black-walnut oil, which is obtained from the nuts of *Juglans nigra*, is commercially classified as a drying oil. When free from fatty acid, it is said to be preferred to any other oil for making artists' white paints, since it makes them less liable to crack than if prepared with linseed oil. Black walnuts are rich in oil,² 56 per cent being contained in the edible portion, and when subjected to pressure yield a yellow oil possessing the characteristic odor and flavor of the nuts. Although this flavor is esteemed by many, it is somewhat too pronounced to make this oil as generally adaptable for cooking or salad purposes as the others here considered.

A supply of first quality nuts was obtained from a local dealer. The kernels were ground in a common household meat chopper, after which the oil was extracted by hydraulic pressure without heating; approximately a 50 per cent yield resulting.

In all other determinations of the coefficients of digestibility of the many fats included in this series, the basal ration served in conjunction with the blancmange, which contained the fat under consideration, consisted of wheat biscuit, fruit, sugar, and tea or coffee if desired. The basal ration served in the experiments with the black-walnut oil was of a slightly different composition, because, owing to the exhaustion of the available supply of the wheat biscuit, it became necessary to replace them by crackers. However, since the composition of the crackers was quite similar to that of the wheat biscuit, it is not thought that this change in the basal ration has in any way vitiated the values obtained in these experiments for comparison with values obtained for the digestibility of other oils studied.

Four young men of normal health and activity served as subjects for the tests made with the black-walnut oil; the following tables contain the essential data for interpreting the results obtained.

¹ U. S. Dept. Agr. Bul. 310 (1915).

² U. S. Dept. Agr., Office Expt. Stas. Bul. 28 (1906), rev. ed.

Data of digestion experiments with black-walnut oil in a simple mixed diet.

Experiment, subject, and diet.	Weight of foods.	Constituents of foods.				
		Water.	Protein.	Fat.	Carbo-hydrates.	Ash.
Experiment No. 565, subject H. R. G.:	<i>Grams.</i>	<i>Grams.</i>	<i>Grams.</i>	<i>Grams.</i>	<i>Grams.</i>	<i>Grams.</i>
Blanemange containing black-walnut oil ..	1,406.0	685.6	27.3	127.1	555.2	10.8
Crackers.....	288.0	19.9	23.3	38.6	203.9	2.3
Fruit.....	464.0	403.2	3.7	1.0	53.8	2.3
Sugar.....						
Total food consumed.....	2,158.0	1,108.7	54.3	166.7	812.9	15.4
Feces.....	51.0		19.5	6.5	20.2	4.8
Amount utilized.....			34.8	160.2	792.7	10.6
Per cent utilized.....			64.1	96.1	97.5	68.8
Experiment No. 566, subject A. J. H.:						
Blanemange containing black-walnut oil ..	1,800.0	877.7	34.9	162.7	710.8	13.9
Crackers.....	132.0	9.1	10.7	17.7	93.5	1.0
Fruit.....	145.0	126.0	1.2	.3	16.8	.7
Sugar.....	85.0				85.0	
Total food consumed.....	2,162.0	1,012.8	46.8	180.7	906.1	15.6
Feces.....	70.0		25.5	14.6	22.7	7.2
Amount utilized.....			21.3	166.1	883.4	8.4
Per cent utilized.....			45.5	91.9	97.5	53.8
Experiment No. 567, subject P. K.:						
Blanemange containing black-walnut oil ..	2,115.0	1,031.3	41.0	191.2	835.2	16.3
Crackers.....	308.0	21.2	24.9	41.3	218.1	2.5
Fruit.....	788.0	684.8	6.3	1.6	91.4	3.9
Sugar.....	100.0				100.0	
Total food consumed.....	3,311.0	1,737.3	72.2	234.1	1,244.7	22.7
Feces.....	47.0		17.4	7.8	17.0	4.8
Amount utilized.....			54.8	226.3	1,227.7	17.9
Per cent utilized.....			75.9	96.7	98.6	78.9
Experiment No. 568, subject C. J. W.:						
Blanemange containing black-walnut oil ..	2,125.0	1,036.1	41.2	192.1	839.2	16.4
Crackers.....	293.0	20.2	23.7	39.3	207.5	2.3
Fruit.....	792.0	688.2	6.3	1.6	91.9	4.0
Sugar.....	74.0				74.0	
Total food consumed.....	3,284.0	1,744.5	71.2	233.0	1,212.6	22.7
Feces.....	81.0		29.4	12.8	30.8	8.0
Amount utilized.....			41.8	220.2	1,181.8	14.7
Per cent utilized.....			58.7	94.5	97.5	64.8
Average food consumed per subject per day...	909.6	466.9	20.4	67.9	348.0	6.4

Summary of digestion experiments with black-walnut oil in a simple mixed diet.

Experiment No.	Subject.	Protein.	Fat.	Carbo-hydrates.	Ash.
		<i>Per cent.</i>	<i>Per cent.</i>	<i>Per cent.</i>	<i>Per cent.</i>
565.....	H. R. G.....	64.1	96.1	97.5	68.8
566.....	A. J. H.....	45.5	91.9	97.5	53.8
567.....	P. K.....	75.9	96.7	98.6	78.9
568.....	C. J. W.....	58.7	94.5	97.5	64.8
	Average.....	61.1	94.8	97.8	66.6

It will be noted from the above data of the digestion experiments with black-walnut oil that the total fat of the diet was 94.8 per cent digested. On an average 56 grams of black-walnut oil were eaten per man per day. If allowance is made for the ether-extracted material resulting from the nonfatty portion of the diet, the digestibility of

black-walnut oil becomes 97.5 per cent. The protein and carbohydrate portions of the diet were 61.1 per cent and 97.8 per cent digested, respectively, figures comparing favorably with those usually obtained for these constituents in other tests of this series, and indicating that this oil does not decrease the digestibility of other food materials consumed in conjunction with it.

BRAZIL-NUT OIL.

Brazil-nut oil is obtained from the seeds of *Bertholletia excelsa*, which is indigenous to tropical South America, and which occurs there in both the wild and the cultivated state. These nuts are especially rich in oil, which, according to Lewkowitsch,¹ may make up as much as 73 per cent of the dried nuts.

The oil, obtained by cold pressing a quantity of fresh Brazil nuts, was odorless and nearly colorless, and possessed a flavor similar to that of the nuts, though very much less pronounced.

Jaffa² studied the digestibility of Brazil nuts when eaten as a part of diets containing such foods as apples, bananas, granose (a wheat preparation), grapes, honey, milk, olive oil, and tomatoes. In the three experiments an average of 106 grams of fat was eaten daily, with an average digestibility of 89 per cent (91.2 per cent, 84.3 per cent, 91.5 per cent) for the total fat, of which 92 per cent was Brazil-nut oil.

The following experiments were made to determine the digestibility of Brazil-nut oil under conditions similar to those in the other experiments in the present series.

Data of digestion experiments with Brazil-nut oil in a simple mixed diet.

Experiment, subject, and diet.	Weight of foods.	Constituents of foods.				
		Water.	Protein.	Fat.	Carbo-hydrates.	Ash.
Experiment No. 551, subject H. R. G.:	<i>Grams.</i>	<i>Grams.</i>	<i>Grams.</i>	<i>Grams.</i>	<i>Grams.</i>	<i>Grams.</i>
Blancmange containing Brazil-nut oil.....	1,399.0	657.4	26.1	168.9	534.4	12.2
Wheat biscuit.....	259.0	23.3	27.5	3.9	200.2	4.1
Fruit.....	874.0	759.5	7.0	1.7	101.4	4.4
Sugar.....	56.0				56.0	
Total food consumed.....	2,588.0	1,440.2	60.6	174.5	892.0	20.7
Feces.....	74.0		24.3	7.4	36.4	5.9
Amount utilized.....			36.3	167.1	855.6	14.8
Per cent utilized.....			59.9	95.8	95.9	71.5
Experiment No. 553, subject P. K.:						
Blancmange containing Brazil-nut oil	2,185.0	1,026.7	40.9	263.7	834.7	19.0
Wheat biscuit.....	452.0	40.7	47.9	6.8	349.4	7.2
Fruit.....	866.0	752.6	6.9	1.7	100.5	4.3
Sugar.....	37.0				37.0	
Total food consumed.....	3,540.0	1,820.0	95.7	272.2	1,321.6	30.5
Feces.....	85.0		26.1	12.9	38.8	7.2
Amount utilized.....			69.6	259.3	1,282.8	23.3
Per cent utilized.....			72.7	95.3	97.0	76.4

¹ Chemical Technology and Analysis of Oils, Fats, and Waxes. London: Macmillan & Co. (Ltd.), 1909, 4 ed., vol. 2, p. 188.

² Loc. cit.

Data of digestion experiments with Brazil-nut oil in a simple mixed diet—Contd.

Experiment, subject, and diet.	Weight of foods.	Constituents of foods.				
		Water.	Protein.	Fat.	Carbo-hydrates.	Ash.
Experiment No. 554, subject C. J. W.:	<i>Grams.</i>	<i>Grams.</i>	<i>Grams.</i>	<i>Grams.</i>	<i>Grams.</i>	<i>Grams.</i>
Blancmange containing Brazil-nut oil.....	2,477.0	1,163.9	46.3	299.0	946.2	21.6
Wheat biscuit.....	332.0	29.9	35.2	5.0	256.6	5.3
Fruit.....	1,045.0	908.1	8.4	2.1	121.2	5.2
Sugar.....						
Total food consumed.....	3,854.0	2,101.9	89.9	306.1	1,324.0	32.1
Feces.....	128.0		38.8	23.6	51.1	14.5
Amount utilized.....			51.1	282.5	1,272.9	17.6
Per cent utilized.....			56.8	92.3	96.1	54.8
Average food consumed per subject per day...	1,109.1	595.8	27.4	83.6	393.1	9.2

Summary of digestion experiments with Brazil-nut oil in a simple mixed diet.

Experiment No.	Subject.	Protein.	Fat.	Carbo-hydrates.	Ash.
		<i>Per cent.</i>	<i>Per cent.</i>	<i>Per cent.</i>	<i>Per cent.</i>
551.....	H. R. G.....	59.9	95.8	95.9	71.5
553.....	P. K.....	72.7	95.3	97.0	76.4
554.....	C. J. W.....	56.8	92.3	96.1	54.8
	Average.....	63.1	94.5	96.3	67.6

As indicated by the above experiments the digestibility of the protein, fat, and carbohydrate portions of the diet was 63.1 per cent, 94.5 per cent, and 96.3 per cent, respectively. The value for the digestibility of the total fat of the diet, 94.5 per cent, is increased to 96.3 per cent for Brazil-nut oil alone when account is taken of the metabolic products and any undigested portion of the fat supplied by the basal ration.

The high digestibility of Brazil-nut oil and the relatively high digestibility of Brazil nuts as a whole, as reported by Jaffa,¹ would indicate that from a dietetic standpoint these nuts are worthy the high place accorded them as food.

BUTTERNUT OIL.

The kernel of the butternut (*Juglans cinerea*) when subjected to pressure yields a light yellow oil which apparently has received little attention from investigators. No report was found in the literature of any study of its physical and chemical properties, its use for industrial or edible purposes, or its nutritive value. In view of the high fat content of butternuts—it is reported² that the kernels contain over 61 per cent of oil—and of the rather extensive use of butter-

¹ U. S. Dept. Agr., Office Expt. Stas. Bul. 132 (1903).

² U. S. Dept. Agr., Office Expt. Stas. Bul. 28 (1899), p. 74, rev. ed.

nuts in some localities, it appeared desirable to determine the digestibility of butternut oil for comparison with the values obtained for the digestibility of other nut oils.

Since it was impossible to procure any butternut oil in the market, 2 bushels of nuts were secured in northern New England. When these had been thoroughly dried the kernels were removed and the oil expressed (cold pressed) with a hydraulic press. The freshly made oil possessed the qualities of a good salad oil and did not exhibit in any appreciable degree the characteristic butternut flavor. The chemical and physical properties of this oil were studied by R. H. Kerr, of the Bureau of Animal Industry, whose report describes it as: A clear, golden yellow oil of mild, pleasant odor, and agreeable taste. The refractive index at 40° was found to be 1.4710, and the iodine number 156.90.

In this study of its digestibility, the butternut oil was, as usual, incorporated in a cornstarch blancmange and served in conjunction with the customary basal ration. Three subjects assisted in this study and the results which were obtained are reported in the table which follows:

Data of digestion experiments with butternut oil in a simple mixed diet.

Experiment, subject, and diet	Weight of foods.	Constituents of foods.				
		Water.	Protein.	Fat.	Carbo-hydrates.	Ash.
Experiment No. 732, subject R. F. C.:	<i>Grams.</i>	<i>Grams.</i>	<i>Grams.</i>	<i>Grams.</i>	<i>Grams.</i>	<i>Grams.</i>
Blancmange containing butternut oil...	1,205.0	589.3	27.5	109.3	473.1	5.8
Wheat biscuit.....	400.0	36.0	42.4	6.0	309.2	6.4
Fruit.....	1,381.0	1,200.1	11.0	2.8	160.2	6.9
Sugar.....	184.0				184.0	
Total food consumed.....	3,170.0	1,825.4	80.9	118.1	1,126.5	19.1
Feces.....	118.0		44.1	17.4	42.9	13.6
Amount utilized.....			36.8	100.7	1,083.6	5.5
Per cent utilized.....			45.5	85.3	96.2	28.8
Experiment No. 733, subject P. K.:						
Blancmange containing butternut oil....	1,460.0	714.1	33.3	132.4	573.2	7.0
Wheat biscuit.....	307.0	27.6	32.6	4.6	237.3	4.9
Fruit.....	691.0	600.5	5.5	1.4	80.2	3.4
Sugar.....	257.0				257.0	
Total food consumed.....	2,715.0	1,342.2	71.4	138.4	1,147.7	15.3
Feces.....	84.0		27.7	19.1	28.9	8.3
Amount utilized.....			43.7	119.3	1,118.8	7.0
Per cent utilized.....			61.2	86.2	97.5	45.8
Experiment No. 734, subject J. C. M.:						
Blancmange containing butternut oil....	1,612.0	788.4	36.8	146.2	632.9	7.7
Wheat biscuit.....	387.0	34.8	41.0	5.8	299.2	6.2
Fruit.....	1,293.0	1,123.6	10.3	2.6	150.0	6.5
Sugar.....	161.0				161.0	
Total food consumed.....	3,453.0	1,946.8	88.1	154.6	1,243.1	20.4
Feces.....	75.0		24.1	8.2	35.3	7.4
Amount utilized.....			64.0	146.4	1,207.8	13.0
Per cent utilized.....			72.6	94.7	97.2	63.7
Average food consumed per subject per day.	1,037.6	568.3	26.7	45.7	390.8	6.1

Summary of digestion experiments with butternut oil in a simple mixed diet.

Experiment No.	Subject.	Protein.	Fat.	Carbo- hydrates.	Ash.
		<i>Per cent.</i>	<i>Per cent.</i>	<i>Per cent.</i>	<i>Per cent.</i>
732.....	R. F. C.....	43.5	85.3	96.2	28.8
733.....	P. K.....	61.2	86.2	97.5	45.8
734.....	J. C. M.....	72.6	94.7	97.2	63.7
	Average.....	59.8	88.7	97.0	46.1

The supply of butternut oil obtainable was small and so it was not possible to provide as large a quantity of it per day as was the case with the other oils studied, and the average daily consumption was only 46 grams per man. The butternut-oil blancmange was as palatable as the similar dish used in the other tests, and there is every reason to believe that more of the oil would have been eaten had it been possible to supply a blancmange richer in it. The digestibility of the total fat in the diet was found to be 88.7 per cent. The calculated digestibility of butternut oil alone, which represented the greater part of the total fat, when estimated in the usual manner, with corrections for metabolic products and undigested fat from the basal ration, is 95.4 per cent, a value which compares favorably with the digestibility of other food oils which have been studied.

The protein and carbohydrates supplied by the ration were utilized as completely as in other experiments of this series, being 60 per cent and 97 per cent digested, respectively. Considering the results as a whole, it is apparent that butternut oil, expressed from fresh, sound butternuts, when eaten as a constituent of a simple mixed diet, is a well assimilated and palatable food oil.

ENGLISH-WALNUT OIL.

The English or Persian walnut tree (*Juglans regia*) is widely distributed, and the nuts are very generally used for human food. English-walnut oil is expressed for illuminating and for edible purposes in several parts of Europe. The cold-pressed oil is almost colorless and has a pleasant smell and agreeable taste, while, according to Lewkowitsch,¹ if hot pressed it has a greenish tinge and acrid taste and odor.

A survey of the literature revealed little information as regards the digestibility of English-walnut oil. Jaffa¹ made a series of 11 digestion experiments in which he studied the digestibility of walnuts eaten in conjunction with other common food materials. On an average the subjects ate 97 grams of fat per day, of which 86 grams was walnut oil. The digestibility of the total fat of the diet was 85 per cent. Since the fat derived from the other constituents of the

¹ Loc. cit.

diet (grapes, granose, pears, milk, apples, dried figs, bananas, oranges, dried prunes, dates) is believed to be very well utilized by the human body, the results of these experiments would indicate that the coefficient of digestibility of walnut oil eaten as a constituent of the nuts would not be far from 85 per cent.

In the experiments here reported the walnut oil, which was cold pressed from a good grade of nuts, was fed in the usual manner to three healthy young men, and the data obtained are recorded in the following table:

Data of digestion experiments with English-walnut oil in a simple mixed diet.

Experiment, subject, and diet.	Weight of foods.	Constituents of foods.				
		Water.	Protein.	Fat.	Carbohydrates.	Ash.
Experiment No. 355, subject D. G. G.:	<i>Grams.</i>	<i>Grams.</i>	<i>Grams.</i>	<i>Grams.</i>	<i>Grams.</i>	<i>Grams.</i>
Blancmange containing walnut oil.....	1,736.0	918.7	32.5	209.7	566.8	8.3
Wheat biscuit.....	402.0	36.2	42.6	6.0	310.8	6.4
Fruit.....	705.0	612.7	5.6	1.4	81.8	3.5
Sugar.....	107.0				107.0	
Total food consumed.....	2,950.0	1,567.6	80.7	217.1	1,066.4	18.2
Feces.....	86.0		29.1	9.5	39.4	8.0
Amount utilized.....			51.6	207.6	1,027.0	10.2
Per cent utilized.....			63.9	95.6	96.3	56.0
Experiment No. 356, subject R. L. S.:						
Blancmange containing walnut oil.....	2,081.0	1,101.3	38.9	251.4	679.4	10.0
Wheat biscuit.....	339.0	30.5	35.9	5.1	262.1	5.4
Fruit.....	450.0	391.0	3.6	0.9	52.2	2.3
Sugar.....	96.0				96.0	
Total food consumed.....	2,966.0	1,522.8	78.4	257.4	1,089.7	17.7
Feces.....	60.0		19.8	12.4	21.8	6.0
Amount utilized.....			58.6	245.0	1,067.9	11.7
Per cent utilized.....			74.7	95.2	98.0	66.1
Experiment No. 357, subject O. E. S.:						
Blancmange containing walnut oil.....	2,026.0	1,072.2	37.9	244.7	661.5	9.7
Wheat biscuit.....	310.0	27.9	32.9	4.6	239.6	5.0
Fruit.....	1,341.0	1,165.3	10.7	2.7	155.6	6.7
Sugar.....	229.0				229.0	
Total food consumed.....	3,906.0	2,265.4	81.5	252.0	1,285.7	21.4
Feces.....	88.0		24.3	19.0	33.5	11.2
Amount utilized.....			57.2	233.0	1,252.2	10.2
Per cent utilized.....			70.2	92.5	97.4	47.7
Average food consumed per subject per day...	1,091.3	595.1	26.7	80.7	382.4	6.4

Summary of digestion experiments with English-walnut oil in a simple mixed diet.

Experiment No.	Subject.	Protein.	Fat.	Carbohydrates.	Ash.
		<i>Per cent.</i>	<i>Per cent.</i>	<i>Per cent.</i>	<i>Per cent.</i>
355.....	D. G. G.....	63.9	95.6	96.3	56.0
356.....	R. L. S.....	74.7	95.2	98.0	66.1
357.....	O. E. S.....	70.2	92.5	97.4	47.7
	Average.....	69.6	94.4	97.2	56.6

The average coefficient of digestibility of the total fat of the diet is 94.4 per cent. If proper allowance is made for the metabolic products and the undigested fat remaining from the basal ration it becomes 97.6 per cent for English-walnut oil alone. The protein and carbohydrate of the diet are shown to be 69.6 per cent and 97.2 per cent digested, respectively.

The difference between the coefficient of digestibility, 97.6 per cent, obtained in these experiments and the 85 per cent or less obtained by Jaffa¹ in his series of 11 digestion experiments, in which the whole nuts were eaten, is thought to be due in part to the form in which the oil was used and may be due in part to Jaffa's considering the ether extract of whole nuts as fat whereas substances other than fat were doubtless extracted, and also may be due in part to no correction being made for metabolic products occurring in the ether extract of the feces. In the latter case it was taken as a constituent of the nut and was probably less readily and completely acted upon by the digestive juices than when it had been mechanically separated and was taken as a separated fat.

The subjects consumed on an average 78 grams (69.9 grams, 83.8 grams, 81.6 grams) of English-walnut oil daily. All three of the subjects reported a laxative effect as a result of the diet; one experienced the effect at the beginning of the test period, one at the end, and one during the entire experimental period. Accordingly, it is believed that the limit of tolerance for this oil is not greatly in excess of 80 grams daily.

HICKORY-NUT OIL.

The oil of the hickory nut (*Carya ovata*) is not separated for edible purposes in this country. It is not without interest to note, however, that the American Indians used hickory-nut oil for food purposes. The oil, according to Carr,² was obtained by mixing the pounded nuts in boiling water, straining off the oily liquid, and skimming off the oil which floated on the water in which the nuts were boiled. "[They] kept it in gourds or earthen pots, etc., using it as we do butter on their bread or to give body and flavor to their broth when meat was scarce."²

Carr also states that oil was obtained from acorns and used in a similar way.

The digestibility of hickory-nut oil is of interest in view of the large quantities of hickory nuts eaten yearly and especially since the edible portion is reported³ to contain 67 per cent of oil.

¹ Loc. cit.

² Proc. Amer. Antiquarian Soc., n. ser., 10 (1895), pp. 171, 172, 181. "The Food of Certain American Indians and their Methods of Preparing It."

³ U. S. Dept. Agr., Office Expt. Stas. Bul. 28 (1906), rev. ed., p. 75.

Since it was impossible to purchase edible hickory-nut oil, a quantity sufficient for the purpose of this investigation was obtained by cold pressing a good grade of nuts purchased in the open market. The resulting oil, which was taken to represent average hickory-nut oil, was of a pale yellow color, without odor, and had a flavor resembling somewhat the nuts from which it was obtained. The supply of oil was very limited, and so no tests were made of its value for table purposes.

The oil, incorporated in the blancmange in the usual manner, was considered only from the standpoint of digestibility, and no attempt was made to determine how much of the oil can be used without producing a laxative effect (limit of tolerance), though it may be assumed that the amount is in excess of that taken in these experiments. The data obtained are given in the following table:

Data of digestion experiments with hickory-nut oil in a simple mixed diet.

Experiment, subject, and diet.	Weight of foods.	Constituents of foods.				
		Water.	Protein.	Fat.	Carbo-hydrates.	Ash.
	Grams.	Grams.	Grams.	Grams.	Grams.	Grams.
Experiment No. 601, subject A. J. H.:						
Blancmange containing hickory-nut oil . . .	1,807.0	811.8	38.4	253.0	696.9	6.9
Wheat biscuit.	190.0	17.1	20.1	2.9	146.9	3.0
Fruit.						
Sugar.						
Total food consumed.	1,997.0	828.9	58.5	255.9	843.8	9.9
Feces.	21.0		7.6	4.1	6.8	2.5
Amount utilized.			50.9	251.8	837.0	7.4
Per cent utilized.			87.0	98.4	99.2	74.7
Experiment No. 602, subject P. K.:						
Blancmange containing hickory-nut oil . . .	2,327.0	1,045.5	49.5	325.8	897.4	8.8
Wheat biscuit.	402.0	36.2	42.6	6.0	310.8	6.4
Fruit.	770.0	669.1	6.2	1.5	89.3	3.9
Sugar.	162.0				162.0	
Total food consumed.	3,661.0	1,750.8	98.3	333.3	1,459.5	19.1
Feces.	64.0		20.0	9.8	28.0	6.2
Amount utilized.			78.3	323.5	1,431.5	12.9
Per cent utilized.			79.7	97.1	98.1	67.5
Experiment No. 603, subject J. C. M.:						
Blancmange containing hickory-nut oil . . .	1,796.0	807.0	38.2	251.4	692.6	6.8
Wheat biscuit.	245.0	22.0	26.0	3.7	189.4	3.9
Fruit.	682.0	592.7	5.4	1.4	79.1	3.4
Sugar.	114.0				114.0	
Total food consumed.	2,837.0	1,421.7	69.6	256.5	1,075.1	14.1
Feces.	81.0		24.9	8.9	38.7	8.5
Amount utilized.			44.7	247.6	1,036.4	5.6
Per cent utilized.			64.2	96.5	96.4	39.7
Experiment No. 604, subject C. J. W.:						
Blancmange containing hickory-nut oil . . .	2,213.0	994.3	47.0	309.8	853.5	8.4
Wheat biscuit.	360.0	32.4	38.2	5.4	278.3	5.7
Fruit.	576.0	500.5	4.6	1.2	66.8	2.9
Sugar.	81.0				81.0	
Total food consumed.	3,230.0	1,527.2	89.8	316.4	1,279.6	17.0
Feces.	81.0		26.7	10.1	37.1	7.1
Amount utilized.			63.1	306.3	1,242.5	9.9
Per cent utilized.			70.3	96.8	97.1	58.2
Average food consumed per subject per day. . .	977.1	460.7	26.3	96.9	388.2	5.0

Summary of digestion experiments with hickory-nut oil in a simple mixed diet.

Experiment No.	Subject.	Protein.	Fat.	Carbo- hydrates.	Ash.
		<i>Per cent.</i>	<i>Per cent.</i>	<i>Per cent.</i>	<i>Per cent.</i>
601.....	A. J. H.....	87.0	98.4	99.2	74.7
602.....	P. K.....	79.7	97.1	98.1	67.5
603.....	J. C. M.....	64.2	96.5	96.4	39.7
604.....	C. J. W.....	70.3	96.8	97.1	58.2
	Average.....	75.3	97.2	97.7	60.0

The average coefficient of digestibility of the fat eaten, of which over 98 per cent was hickory-nut oil, was 97.2 per cent, while 75.3 per cent of the protein and 97.7 per cent of the carbohydrates were retained in the body. The value for the digestibility of hickory-nut oil alone, obtained by making allowance for the metabolic products and the undigested fat resulting from the accessory foods of the diet, is 99.3 per cent. The subjects consumed an average of 95 grams of hickory-nut oil daily without any physiological disturbances. Thus it may be reasonably concluded that if hickory-nut oil were available in quantity it would prove very satisfactory for food purposes.

PECAN OIL.

This oil is obtained from the nuts of *Carya pecan*, which are native and also largely cultivated in North America. Pecan oil, although it possesses the characteristics of a salad oil, is not expressed for edible purposes on a commercial basis. However, since the wide use of the kernels as food entails a corresponding consumption of the oil, and since the expressed oil appears to be well suited for table purposes, it seemed desirable to include pecan oil among the nut oils to be studied.

No reports of digestion experiments made with pecan oil were found in the literature. Jaffa¹ reports four experiments made to study the relative digestibility of the nuts eaten with fruits. Of a total of 78 grams of fat eaten per man per day, 74 grams was derived from pecans, which were included in a simple diet containing common fruits and nuts. The total fat of the diet was found to be 85 per cent digested, but since over 94 per cent of the entire fat eaten was supplied by the pecans this value should, so far as these results are concerned, approximate the coefficient of digestibility of the oil in pecans. The low value, 85 per cent, may be due partly to the subjects not masticating the nuts to such a degree of fineness that the body could completely assimilate the fat in them.

Four experiments were made in the present series to determine the digestibility of pecan oil when eaten under conditions identical with

¹ Loc. cit.

those maintained for the test periods with other edible fats studied. The results obtained are included in the table which follows.

Data of digestion experiments with pecan oil in a simple mixed diet.

Experiment, subject, and diet.	Weight. of foods.	Constituents of foods.				
		Water.	Protein.	Fat.	Carbo- hydrates.	Ash.
Experiment No. 405, subject D. G. G.:	<i>Grams.</i>	<i>Grams.</i>	<i>Grams.</i>	<i>Grams.</i>	<i>Grams.</i>	<i>Grams.</i>
Blancmange containing pecan oil	1,857.0	864.4	37.2	291.7	655.9	7.8
Wheat biscuit.....	315.0	28.4	33.4	4.7	243.5	5.0
Fruit.....	1,341.0	1,165.3	10.7	2.7	155.6	6.7
Sugar.....	121.0				121.0	
Total food consumed.....	3,634.0	2,058.1	81.3	299.1	1,176.0	19.5
Feces.....	104.0		34.3	19.0	39.5	11.2
Amount utilized.....			47.0	280.1	1,136.5	8.3
Per cent utilized.....			57.8	93.6	96.6	42.6
Experiment No. 406, subject A. J. H.:						
Blancmange containing pecan oil.....	2,474.0	1,151.6	49.5	388.7	873.8	10.4
Wheat biscuit.....	575.0	51.8	60.9	8.6	444.5	9.2
Fruit.....	1,413.0	1,227.9	11.3	2.8	163.9	7.1
Sugar.....	66.0				66.0	
Total food consumed.....	4,528.0	2,431.3	121.7	400.1	1,548.2	28.7
Feces.....	127.0		42.3	19.6	51.1	14.0
Amount utilized.....			79.4	380.5	1,497.1	12.7
Per cent utilized.....			65.2	95.1	96.7	47.6
Experiment No. 407, subject R. L. S.:						
Blancmange containing pecan oil.....	1,780.0	828.6	35.6	279.6	628.7	7.5
Wheat biscuit.....	294.0	26.4	31.2	4.4	227.3	4.7
Fruit.....	969.0	842.1	7.8	1.9	112.4	4.8
Sugar.....	117.0				117.0	
Total food consumed.....	3,160.0	1,697.1	74.6	285.9	1,085.4	17.0
Feces.....	46.0		12.8	8.9	18.4	5.9
Amount utilized.....			61.8	277.0	1,067.0	11.1
Per cent utilized.....			82.8	96.9	98.3	65.3
Experiment No. 408, subject O. E. S.:						
Blancmange containing pecan oil.....	1,834.0	853.7	36.7	288.1	647.8	7.7
Wheat biscuit.....	246.0	22.1	26.1	3.7	190.2	3.9
Fruit.....	1,202.0	1,044.6	9.6	2.4	139.4	6.0
Sugar.....	240.0				240.0	
Total food consumed.....	3,522.0	1,920.4	72.4	294.2	1,217.4	17.6
Feces.....	107.0		30.8	29.0	36.3	10.9
Amount utilized.....			41.6	265.2	1,181.1	6.7
Per cent utilized.....			57.5	90.1	97.0	38.1
Average food consumed per subject per day.....	1,237.0	675.6	29.2	106.6	418.9	6.7

Summary of digestion experiments with pecan oil in a simple mixed diet.

Experiment No.	Subject.	Protein.	Fat.	Carbo- hydrates.	Ash.
		<i>Per cent.</i>	<i>Per cent.</i>	<i>Per cent.</i>	<i>Per cent.</i>
405.....	D. G. G.....	57.8	93.6	96.6	42.6
406.....	A. J. H.....	65.2	95.1	96.7	47.6
407.....	R. L. S.....	82.8	96.9	98.3	65.3
408.....	O. E. S.....	57.5	90.1	97.0	38.1
	Average.....	65.9	93.9	97.2	48.4

The above data indicate that an average of 107 grams of fat, of which 104 grams was pecan oil, was eaten per subject per day for

the four test periods which were made to determine the digestibility of pecan oil. The coefficients of digestibility for the constituents of the diet were for protein, 65.9 per cent; for fat, 93.9 per cent; and for carbohydrates, 97.2 per cent. Experiments made to determine the significance of the ether extract of the feces resulting from the basal ration without the addition of fat have been reported in an earlier paper;¹ making allowance for that portion of the ether extract of the feces which results from the basal ration, the value for the digestibility of the total fat, 93.9 per cent, becomes 96.8 per cent for the pecan oil alone.

CONCLUSIONS.

An average of 70 grams of almond, 56 grams of black-walnut, 81 grams of Brazil-nut, 43 grams of butternut, 78 grams of English-walnut, 95 grams of hickory-nut, and 104 grams of pecan oil was eaten per subject per day in the experiments, out of a total of 71 grams, 68 grams, 84 grams, 46 grams, 80 grams, 97 grams, and 107 grams of fat supplied by the respective diets.

The oils studied in this investigation were found to be well digested, the coefficients of digestibility being 97.1 per cent for almond oil, 97.5 per cent for black-walnut oil, 96.3 per cent for Brazil-nut oil, 95.4 per cent for butternut oil, 97.6 per cent for English-walnut oil, 99.3 per cent for hickory-nut oil, and 96.8 per cent for pecan oil.

The nut oils, which are liquid at ordinary temperatures, have practically the same digestibility as the common vegetable oils (cottonseed, peanut, olive, sesame, and coconut oils), which are also liquid at ordinary temperatures.

While in these experiments as much as 81 grams of almond oil, 64 grams of black-walnut oil, 100 grams of Brazil-nut oil, 49 grams of butternut oil, 109 grams of hickory-nut oil, and 130 grams of pecan oil were eaten per day by one of the subjects for a 3-day test period, no laxative effect was noted; accordingly the limits of tolerance for these fats is in excess of these amounts. In the experiments with English-walnut oil the three subjects ate 69.9 grams, 83.8 grams, and 81.6 grams per day and all reported a slight laxative effect.

The values obtained for the digestibility of the protein and carbohydrates eaten in conjunction with the different nut oils are in agreement with those obtained in the earlier experiments of this series, indicating that the nut oils did not exert any unusual influence on the digestibility of the foods eaten with them.

The results of this study of the digestibility of these nut oils indicate that they are very well assimilated by the human body, and that whenever available they could be used freely for food purposes.

¹ U. S. Dept. Agr. Bul. 310 (1915), p. 17.

**PUBLICATIONS OF UNITED STATES DEPARTMENT OF AGRICULTURE
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- The Detection of Phytosterol in Mixtures of Animal and Vegetable Fats. By R. H. Kerr. Pp. 4. 1913. (Bureau of Animal Industry Circular 212.)
- Some American Vegetable Food Oils, Their Sources and Method of Production. By H. S. Bailey. U. S. Dept. Agr. Yearbook 1916. Pp. 159-176.

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- Studies of the Effect of Different Methods of Cooking upon the Thoroughness and Ease of Digestion of Meats at the University of Illinois. H. S. Grindley, D. Sc., Timothy Mojonner, M. S., and Horace C. Porter, Ph. D. Pp. 100, tables 38. 1907. (Office of Experiment Stations Bulletin 193.) Price, 15 cents.
- Digestibility of Some Animal Fats. By C. F. Langworthy and A. D. Holmes. Pp. 23. 1915. (Department Bulletin 310.) Price, 5 cents.
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UNITED STATES DEPARTMENT OF AGRICULTURE
BULLETIN No. 631

Contribution from the Bureau of Animal Industry
JOHN R. MOHLER, Chief

Washington, D. C.

April 19, 1918

FIVE YEARS' CALF-FEEDING WORK
IN ALABAMA AND MISSISSIPPI

By

W. F. WARD and S. S. JERDAN

Of the Animal Husbandry Division

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I. WINTER FATTENING OF CALVES ON COTTONSEED MEAL, COTTONSEED HULLS, CORN-AND-COB MEAL, AND ALFALFA HAY.

PREVIOUS EXPERIMENTS.

During the winter of 1910-11 (November 17 to March 17) this bureau, working in cooperation with the Alabama Experiment Station, carried on an experiment in fattening calves on various rations. These results are published in Bulletin 147 of the Bureau of Animal Industry and in Bulletin 158 of the Alabama Experiment Station. The first lot of calves was fattened on a ration of cottonseed meal, hulls, and alfalfa hay. The second lot was given a one-third ration of corn-and-cob meal in conjunction with the cottonseed meal, hulls, and hay. The third lot was given a liberal allowance of corn-and-cob meal and a rather small allowance of cottonseed meal, the corn-and-cob meal constituting two-thirds of the concentrated part of the ration. As the work reported in the present bulletin is really a dupli-

¹ This work was done in cooperation with the Alabama Experiment Station, J. F. Duggar, director, and the Mississippi Experiment Station, E. R. Lloyd, director. G. A. Scott, of the Animal Husbandry Division, U. S. Department of Agriculture, assisted in preparing computations.

cation of that previously reported, it will be of interest to introduce the discussion with a short extract from the above-mentioned publication, especially since the two years' work do not agree in all particulars. In the discussion following the financial statement, it was stated that all the calves were fed at a profit (the calves were bought at \$3.50 a hundred pounds and sold for \$5.01, \$5.11, and \$5.26, respectively, in lots 1, 2, and 3), the lowest being \$1.48 per calf in lot 3 and the highest \$2.25 per calf in lot 2. These profits meant that the corn and the hay raised on the farm were sold, through the calves, at 70 cents a bushel and \$15 a ton, respectively; that the money expended for cottonseed meal and hulls was all returned to the owner; that the fertilizer value of these feeds was left on the farm, and, in addition, each calf returned the above additional profits. The monetary returns were satisfactory, as by means of the calves the farm feeds were sold for more than could have been secured for them on the market, and their fertilizing value was left on the farm in the shape of barnyard manure.

The calves in lot 3, which received the heavy ration of corn-and-cob meal, returned the smallest profit, notwithstanding the fact that they sold for the highest price at Cincinnati. The increase in the price did not overcome the added expense of feeding a heavy ration of corn-and-cob meal. Although it did not pay to feed the heavy ration of corn-and-cob meal, it did pay to feed the small amount of corn-and-cob meal that was used in lot 2, as the calves in this lot proved to be the most profitable. This indicates that when fattening beef calves with cottonseed meal and corn-and-cob meal as the concentrates one-third of the concentrated part of the ration can consist profitably of corn-and-cob meal, but it is less profitable to have corn-and-cob meal constitute two-thirds of the concentrated part of the ration.

However, there was one factor that had not been taken into consideration which, if considered, adds to the profits of lots 2 and 3, especially the latter. Some undigested corn passed through the calves in these two lots; hogs following them would have derived no little benefit from the droppings. In fact, several hogs did follow the steers in lot 3, but no record was kept of their gains. These gains should be credited to the calves.

In the present test, hogs followed those calves that were fed a partial ration of corn.

OBJECTS OF WORK.

As with the previous test, the main object in this calf-feeding work was to determine whether the farmer can afford to raise a good grade of beef calves and finish them for the market when they are about a year old. In the South the usual custom is to keep the offspring until they are from 2 to 4 years old before finishing them for the market. Many farmers, however, are now asking if it would not be

more profitable to sell the calves while they are yet young, thus making it possible to increase the size of the breeding herd. As stated before, some results of calf-feeding work have been published; the present publication must be considered only a report of the progress of the work, as the experiments are being continued and new phases studied.

The calves in this test were divided into three lots so that a comparison of the value of certain feeds for fattening young calves could be made. The following problems were studied:

1. The calves were raised on the farm where they were fattened, and one object was to learn whether a farmer profitably can raise and fatten calves for the market by the time they are a year old.

2. To make a comparison of southern feeds and combinations of feeds that may be used for fattening calves during the winter months.

This work was carried on upon the farm of O. E. Cobb, of Sumterville, Ala., with whom the bureau and the station have been in co-operation for a number of years. Mr. Cobb furnished the calves and the feed and the Bureau of Animal Industry and the Alabama Experiment Station provided a trained man to live on the farm and have personal supervision of the experimental work. In this way all the tests were made under average farm conditions and at the same time were executed in an unusually accurate and painstaking manner. The junior author of this bulletin was stationed upon the farm and had personal supervision of the work.

KIND OF CALVES USED.

The calves used in this work were all high-grade animals. They were not, however, uniform in breed and breeding, as Hereford, Shorthorn, Aberdeen-Angus, and Red Polled blood were all represented. The calves, however, were far better than the average raised in the western part of Alabama, as they were from one-half to seven-eighths pure bred. The majority of the calves were raised on the farm where the feeding was done; however, there were not a sufficient number, so some were purchased from neighboring farmers in Sumter County. All had been born the preceding spring, so they were from 6 to 8 months of age when the fattening experiment began. During the summer they had run with their dams on good pasture, and during this time they demanded practically no attention from the owner, except to see that they were salted and dipped. Both the cows and the calves were dipped regularly all through the summer months to reduce the number of ticks.

On November 19, 1911, when the fattening period began, the calves averaged 376 pounds in weight.

GENERAL PLAN OF THE WORK.

When fall arrived and the pastures were exhausted, the calves were taken from their dams and placed in this experiment. The

original intention had been to begin the winter feeding work in the fall just as soon as the pastures were exhausted and the milk flow of the dams diminished, to avoid losing any part of the calf fat, but on account of a short unavoidable delay the feeding was not begun until the above-mentioned date. In the meantime the calves doubtless lost a few pounds in weight after the pastures became short. This, of course, was unfortunate.

The calves were weighed individually on November 16 and 17, and the average of the two weights taken to determine the initial weight. The test began, therefore, on November 17, but on the day previous the calves were tagged and numbered, dehorned, the males castrated, and the whole number divided into three lots as nearly equal in size, quality, and breeding as possible. Each lot of calves was fed from November 17, 1911, to March 3, 1912, a period of 107 days, on the following feeds:

Lot 1. Cottonseed meal; cottonseed hulls; mixed alfalfa hay.

Lot 2. Cottonseed meal, two-thirds; corn-and-cob meal, one-third; cottonseed hulls; mixed alfalfa hay.

Lot 3. Cottonseed meal, one-third; corn-and-cob meal, two-thirds; cottonseed hulls; mixed alfalfa hay.

SHELTER AND LOTS.

The calves were young, so each lot was provided with shelter sufficiently good to turn the cold rains and break the cold north winds. Shelter would not have been necessary for mature steers, but the experience of former work¹ thoroughly demonstrated that young calves will not do well, even this far south, without some protection from the cold winds and rains of the winter months. Each lot of calves was confined in a $\frac{1}{2}$ -acre paddock and the calves had the privilege of staying either in the open lots or under the sheds. The lots were not paved. The winter of 1911-12 was unusually wet, consequently the uncovered parts of the lots became excessively muddy at times. The ground floors of the sheds were always dry, however, so the calves had comfortable and convenient places in which to lie down.

METHOD OF FEEDING AND HANDLING THE CALVES.

The calves were fed twice each day; the first feed was given about 7 o'clock in the morning, and the second at 5 o'clock in the evening. The concentrated feeds were placed in troughs, each of which was about 12 feet long and 3 feet wide. When both cottonseed meal and corn-and-cob meal were used they were mixed thoroughly with the cottonseed hulls. The hay was fed in separate hay racks. The concentrated feeds were fed in such amounts that the troughs were cleaned thoroughly within one hour after feeding, but hay was kept in the racks all the time. Both the troughs and the racks were under

¹Bureau of Animal Industry Bulletin 147 and Alabama Experiment Station Bulletin 158.

sheds, so that the feed never became wet and the calves had comfortable quarters in which to eat. Salt was supplied regularly, and fresh water from a deep well was supplied in clean cement troughs.

As stated above, at the beginning and end of the experiment individual weights were secured on two successive days. During the course of the test the total weight of each lot was secured every 28 days.

CHARACTER AND PRICE OF FEEDS.

Cottonseed meal, corn-and-cob meal, cottonseed hulls, and mixed alfalfa hay were used in this test. The cottonseed meal and the cottonseed hulls were purchased at a local market and hauled to the farm, a distance of 9 miles. The corn for the corn-and-cob meal and the mixed alfalfa hay were grown upon the farm where the test was made. The cottonseed meal was only fair in quality. The corn was of high quality. The whole ears of corn with the shucks were run through a grinder and made into corn-and-cob meal. The hay, made of a mixture of alfalfa and Johnson grass, was bright and had been well cured, but the Johnson grass was somewhat coarse. During a part of the test, from January 10 to February 8, Johnson-grass hay alone was fed, as it was not possible to secure a supply of the mixed hay during this short period.

As stated in the first part of the bulletin, it is always unsatisfactory to render a financial statement in work of this character, as the price of the feeds, as well as of the cattle, varies considerably from time to time and from place to place. The really important data are those showing the daily gains and the amount of feed required to make 100 pounds of gain. In this test the feeds were valued as follows:

Cottonseed meal	-----per ton--	\$26.00
Cottonseed hulls	-----do----	7.00
Corn-and-cob meal	-----do----	20.00
Mixed alfalfa hay	-----do----	14.00

As a matter of fact, the cottonseed meal cost only \$24.50 a ton and the cottonseed hulls \$7.50 a ton, but the above prices were adopted for the sake of uniformity. They represent fairly accurately the average prices of feeds in the State. The prices on the other two feeds represent exactly the market prices when the test was made.

DAILY RATIONS.

The farmer who undertakes to fatten young animals should understand that the younger the animal the greater the skill required to care for and feed it. Young calves should not be cared for and fed in a careless manner. With animals of this class one case of carelessness in overfeeding may retard very seriously the whole future development. Table 1 shows the average amount of feed eaten by each calf daily:

TABLE 1.—Average daily rations (November 7, 1911, to March 3, 1912).

Lot No.	Number of calves.	Ration.	Feed consumed by each calf daily.
			Pounds.
1	16	{Cottonseed meal.....	2.16
		{Cottonseed hulls.....	10.26
		{Mixed alfalfa hay.....	4.31
2	15	{Cottonseed meal, two-thirds.....	2.01
		{Corn-and-cob meal, one-third.....	1.00
		{Cottonseed hulls.....	9.89
		{Mixed alfalfa hay.....	4.16
3	16	{Cottonseed meal, one-third.....	1.23
		{Corn-and-cob meal, two-thirds.....	2.44
		{Cottonseed hulls.....	9.56
		{Mixed alfalfa hay.....	4.05

Each calf in lot 1 ate an average of 2.61 pounds of cottonseed meal, 10.26 pounds of cottonseed hulls, and 4.31 pounds of hay during the whole fattening period of 107 days. It should be understood, however, that these calves were not started off suddenly with these amounts of feeds; they gradually were made accustomed to the feeds, especially cottonseed meal, by beginning with small amounts. For instance, on November 17, the day the test was begun, each calf in this lot was given only 1.5 pounds of cottonseed meal, and this amount was divided equally between two feeds; on this same day each calf ate 7 pounds of cottonseed hulls and 4 pounds of hay. On December 2, or 15 days after the test began, the daily feed of each calf in the test had been raised to 2 pounds of cottonseed meal, 9 pounds of cottonseed hulls, and 4 pounds of hay. By January 13 the daily feed for each calf had been raised to 3 pounds of cottonseed meal, 11 pounds of cottonseed hulls, and a fraction over 4 pounds of hay. The daily allowance of cottonseed meal was not increased after this date.

The calves in lots 2 and 3 were fed somewhat more liberally on the concentrated part of the rations and more sparingly on the roughage parts. This could be done because of the introduction of corn-and-cob meal. Changes in either the amount or the kind of feed should be made gradually, especially when dealing with young animals.

WEIGHTS AND GAINS.

When the first weights were secured; in November, the calves averaged from 6 to 8 months in age. On this date they averaged 376 pounds in weight. Though not large for their age, they were considerably larger than the average for this State. Their dams were large for Alabama cows, probably averaging 1,000 pounds in weight in normal breeding condition, and they should have produced larger calves. In Department Bulletin 73 it is seen that calves averaging 460 pounds at 9½ months of age were gotten from cows which averaged only 630 pounds in weight in their winter form, or about 850

pounds in the summer. The calves, however, had not been pampered in any way during the summer months: they simply had run with their dams on a reasonably good pasture.

Table 2 shows that exceedingly satisfactory gains were secured during this winter test:

TABLE 2.—Weights, total gains, and average daily gains (November 17, 1911, to March 3, 1912).

Lot No.	Number of calves.	Ration.	Average initial weight of calves.	Average final weight of calves.	Total gain of each calf.	Average daily gain of each calf.
			Pounds.	Pounds.	Pounds.	Pounds.
1	16	Cottonseed meal.....	376	584	208	1.94
		Cottonseed hulls.....				
		Mixed alfalfa hay.....				
2	15	Cottonseed meal, two-thirds.....	375	562	187	1.75
		Corn-and-cob meal, one-third.....				
		Cottonseed hulls.....				
3	16	Mixed alfalfa hay.....	376	546	170	1.59
		Cottonseed meal, one-third.....				
		Corn-and-cob meal, two-thirds.....				

The gains were all satisfactory, but an exact reverse of the results secured the previous winter. In the previous year's test the calves that were fed corn-and-cob meal along with the cottonseed meal gained more rapidly than those that ate cottonseed meal as the sole concentrate, and the greater the amount of corn-and-cob meal eaten the more rapid the gains. The calves in lot 1, which ate cottonseed meal, gained at an average daily rate of 1.94 pounds, while the calves in lots 2 and 3, where the cottonseed meal was supplemented and partly replaced by corn-and-cob meal gained at the respective rates of 1.75 and 1.59 pounds daily. The only explanation that can be offered is that the calves of all lots were fed more concentrate per head daily during the winter of 1910-11 than they were during the winter of 1911-12, and the amount of concentrates fed for lots 2 and 3 in 1911-12 was too small to make large gains on fattening calves.

When sold, March 3, 1912, these calves were, on the average, about 12 months old. Those in lot 1 had attained an average weight of 584 pounds, but those in lots 2 and 3 were somewhat lighter. Although not large, these calves were perhaps as large at 12 months as the average southern steer at twice the age. The increased size was due partly to the infusion of some good beef blood and partly to liberal feeding and good care.

QUANTITY AND COST OF FEED REQUIRED TO MAKE 100 POUNDS OF GAIN.

The finishing or fattening period continued from November 17, 1911, to March 3, 1912, a period of 107 days. During this time the calves were fed practically all they would eat, especially of the

roughages, hay and hulls. The grain part of the rations was limited in every case to a definite and rather small amount. But Table 2 shows that satisfactory gains were obtained, and Table 3 shows that the cost to make 100 pounds of gain was not excessive, although the feeds used were all expensive ones. In fact, the gains were made cheaply in every case, much more cheaply than can be made with older animals, the cost per hundred pounds ranging from \$5.14 to \$6.43. In the previous winter's work it cost from \$6.19 to \$6.83 to make 100 pounds of increase in weight where the same kind of calves were used and the same kind of feeds employed, yet in referring to the cheapness of gains of the calves the authors stated that—

The gains were made cheaply. This was due to several factors. First, the calves were young and growing, and young animals of all kinds can be made to increase in weight more economically than old ones. Second, the calves were very thrifty, and so made good use of the feed that they ate. Third, all of the rations were extremely palatable, especially the two which had the corn-and-cob meal mixed with the cottonseed meal. A young animal of any kind will not make satisfactory gains on an unpalatable ration. Fourth, the calves had comfortable quarters and were fed and watered regularly.

TABLE 3.—Quantity and cost of feed required to make 100 pounds of gain (Nov. 17, 1911, to Mar. 3, 1912, 107 days).

Lot No.	Ration.	Total amount of feed eaten by each calf.	Pounds of feed to make 100 pounds of gain.	Cost of feed to make 100 pounds of gain.
		<i>Pounds.</i>	<i>Pounds.</i>	
1	Cottonseed meal.....	279	134	\$5.14
	Cottonseed hulls.....	1,098	528	
	Mixed alfalfa hay.....	462	222	
2	Cottonseed meal, two-thirds.....	215	115	5.72
	Corn-and-cob meal, one-third.....	107	58	
	Cottonseed hulls.....	1,058	566	
3	Mixed alfalfa hay.....	445	238	6.43
	Cottonseed meal, one-third.....	130	77	
	Corn-and-cob meal, two-thirds.....	260	154	
	Cottonseed hulls.....	1,023	602	
	Mixed alfalfa hay.....	423	255	

The calves in lot 1, where cottonseed meal, hulls, and mixed hay were used, made the cheapest gains, each 100 pounds of gain in the lot, costing only \$5.14, whereas an equal amount of increase in weight in lots 2 and 3, where corn-and-cob meal constituted a part of the ration, cost \$5.72 and \$6.43, respectively. In this test the corn-and-cob meal did not cheapen the ration in either case. In the test previously reported, the introduction of a small amount of corn-and-cob meal did decrease the cost a few cents, but where the larger proportion of corn-and-cob meal was employed it cost more to make 100 pounds of gain than in the lot where cottonseed meal was the sole concentrated feed. Lot 3 in both experiments showed up to a considerable disadvantage. When the two tests are considered together, sufficient evidence is at hand to show conclusively that it does not

pay to replace two-thirds of the cottonseed meal part of the ration by corn-and-cob meal when cottonseed meal can be bought at \$26 a ton and corn costs 70 cents a bushel.

In lot 1 only 134 pounds of cottonseed meal, 528 pounds of cottonseed hulls, and 222 pounds of hay were required to produce a gain in weight of 100 pounds; this was an extremely satisfactory outcome. In lot 2, where one-third of the grain part of the ration was made up of corn-and-cob meal, to make an equal number of pounds of increase required 115 pounds of cottonseed meal, 58 pounds of corn-and-cob meal, 566 pounds of hulls, and 238 pounds of hay. The introduction, therefore, of the corn-and-cob meal caused a corresponding increase in both the total pounds of grain and roughage required to make 100 pounds of gain. In lot 3, where two-thirds of the grain part of the ration was made up of corn-and-cob meal, to make 100 pounds of increase in weight required the use of 77 pounds of cottonseed meal, 154 pounds of corn-and-cob meal, 602 pounds of cottonseed hulls, and 255 pounds of hay. This was unsatisfactory indeed when compared with the results obtained in lot 1, where no corn-and-cob meal was used.

This test indicates that while cottonseed meal and hulls are cheap, and corn and farm-grown roughage, such as hay, are high-priced, it pays better to purchase such commercial feeds as cottonseed meal and hulls than to purchase corn and hay for fattening calves. However, the boll weevil and the campaign for diversified farming are causing a change in the farming methods of the South, with the result that corn will be raised to a greater extent, a surplus being produced in some sections, and more forage will be raised. The by-products from such farming usually will have to be fed on the farm, and will be much cheaper than the prices charged here. Then, too, such feeds will be produced by many farmers who can not market them because of remoteness from markets, poor roads, poor shipping facilities or high freight rates, and lack of knowledge about the proper preparation of such feeds for the market. Under such conditions the feeds can be used profitably for the stock.

With the prices of feeds charged in this experiment, if all profit is reckoned as the price received for the corn fed, the calves of lot 2 returned \$3.57 per bushel for each bushel of corn consumed, and those of lot 3 returned \$1.62 per bushel for the corn. Or, if all feeds except hay are charged at market prices and the profit is considered as the price received for the hay consumed, the hay was sold by means of the calves at prices ranging from \$29.81 to \$37.43 per ton.

In this experiment it paid, and paid well, to buy both cottonseed meal and hulls and sell them by means of the calves; but it was also very profitable to use the calves as a means of marketing the hay and the corn which were grown upon the farm.

SLAUGHTER DATA.

At the close of the test the calves which had been sold by farm weights were shipped to Meridian, Miss., where complete individual slaughter records were secured. Immediately after securing the final farm weights the calves were driven from the farm to Epes, Ala., a distance of 9 miles, to be shipped. They were on the cars approximately 14 hours, and were fed and watered once after reaching their destination and before the final weights were taken.

Table 4.—Slaughter data.

Lot No.	Ration.	Average final farm weight.	Average final farm weights after 3 per cent shrinkage.	Average market weight.	Average loss in shipping.	Percentage dressed out by farm weights.	Percentage dressed out by market weights.
		<i>Pounds.</i>	<i>Pounds.</i>	<i>Pounds.</i>	<i>Pounds.</i>	<i>Per cent.</i>	<i>Per cent.</i>
1	Cottonseed meal.....	562	545	500	62	46.3	50.56
	Cottonseed hulls.....						
	Mixed alfalfa hay.....						
2	Cottonseed meal, two-thirds.....	552	535	489	63	47.3	51.8
	Corn-and-cob meal, one-third.....						
	Cottonseed hulls.....						
	Mixed alfalfa hay.....	539	523	487	52	46.3	49.7
3	Cottonseed meal, one-third.....						
	Corn-and-cob meal, two-thirds.....						
	Cottonseed hulls.....						
	Mixed alfalfa hay.....						

The calves lost heavily in weight, as a result of being shipped. Those in lots 1 and 2 lost practically the same, 62 and 63 pounds, respectively, but those in lot 3, where more corn-and-cob meal was used, did not suffer such great losses, as each calf in this lot shrank only 52 pounds. The last two columns of Table 4 show that the calves were not very fat as compared with corn-fed cattle of the North. They were, however, in good killing condition and suited the local market demand. The animals in lots 1 and 2 dressed out, by market weights, practically the same, 50.56 per cent and 51.8 per cent, respectively. Those in the third lot were not so well finished, as shown by the fact that they dressed out only 49.7 per cent by their market weight.

Taken as a whole, the shrinkage on these calves amounted to 10.7 per cent of their final farm weight. The shipping distance was 40 miles, but it is not probable that they would have suffered a very much greater loss in weight had the distance been three or four times as great, for it is very probable that the greatest portion of the loss in weight occurred during the drive to the loading point.

FINANCIAL STATEMENT.

The majority of these calves were raised on the farm on which they were fattened. A few, however, were purchased from neighboring farmers; those purchased cost 4 cents a pound, and as they very accurately represented an average of the whole number, the initial or fall value of all was placed at 4 cents a pound on the farm without shrinkage. When they were ready to be marketed buyers visited the farm and made bids. They were sold to a buyer of Meridian, Miss., for 5½ cents a pound on the farm, after a 3 per cent deduction on farm weights. The buyer, therefore paid all expenses of shipping.

The following statements show the complete financial record:

TABLE 5.—*Financial statement.*

Lot 1. Cottonseed meal, cottonseed hulls, mixed alfalfa hay:	
To 16 calves—6,010 pounds, at 4 cents a pound-----	\$240.40
To 4,466 pounds of cottonseed meal, at \$26 a ton-----	58.06
To 17,568 pounds of cottonseed hulls, at \$7 a ton-----	61.49
To 7,380 pounds of mixed alfalfa hay, at \$14 a ton-----	51.66
Total expenditures-----	411.61
By sale of 16 calves—9,336 pounds, at 5½ cents a pound-----	498.07
Total profit on lot-----	86.46
Average profit on each calf-----	5.40
Lot 2. Cottonseed meal two-thirds, corn-and-cob meal one-third, cottonseed hulls, mixed alfalfa hay:	
To 15 calves—5,623 pounds, at 4 cents a pound-----	224.92
To 3,220 pounds of cottonseed meal, at \$26 a ton-----	41.86
To 1,610 pounds of corn-and-cob meal, at \$20 a ton-----	16.10
To 15,872 pounds of cottonseed hulls, at \$7 a ton-----	55.55
To 6,677 pounds of mixed alfalfa hay, at \$14 a ton-----	46.74
Total expenditures-----	385.17
By sale of 15 calves—8,430 pounds, at 5½ cents a pound-----	449.74
Total profit on lot-----	64.57
Average profit on each calf-----	4.30
Lot 3. Cottonseed meal one-third, corn-and-cob meal two-thirds, cottonseed hulls, mixed alfalfa hay:	
To 16 calves—6,010 pounds, at 4 cents a pound-----	240.40
To 2,083 pounds of cottonseed meal, at \$26 a ton-----	27.08
To 4,166 pounds of corn-and-cob meal, at \$20 a ton-----	41.66
To 16,370 pounds of cottonseed hulls, at \$7 a ton-----	57.30
To 6,932 pounds of mixed alfalfa hay, at \$14 a ton-----	48.52
Total expenditures-----	414.96
By sale of 16 calves—8,730 pounds, at 5½ cents a pound-----	480.15
Total profit on lot-----	65.19
Average profit on each calf-----	4.07

As previously stated, hogs followed the calves that had a partial ration of corn-and-cob meal and received some benefit from the droppings. This item does not appear in the above financial statement, but it is discussed in a later paragraph.

Leaving out of consideration for the present the results secured from the hogs, it is seen that the greatest profit was realized on the calves that were fed cottonseed meal, cottonseed hulls, and mixed alfalfa hay. It did not pay to feed the corn-and-cob meal along with the cottonseed meal at the prevailing prices of the two feeds, and the greater the proportion of corn used the smaller the resultant profits. In lot 1 each calf returned a clear profit of \$5.40; but in lot 2, where one-third of the cottonseed meal was replaced by corn-and-cob meal, a profit of only \$4.30 was made on each animal; and in lot 3, where two-thirds of the cottonseed meal was replaced by corn-and-cob meal, the profit per calf dropped to \$4.07. All the profits, however, were satisfactory; but, leaving out of consideration the profits derived from the hogs, the cottonseed meal ration proved to be the most profitable.

HOGS FOLLOWING CALVES.

It was thought that if hogs were allowed to follow the calves that ate a partial ration of corn-and-cob meal they would derive some benefit from the undigested corn in the droppings. In a former test¹ an effort was made to get some benefit from the droppings when the steers ate nothing except cottonseed meal as the concentrate, but this ended in a failure, so no pigs were placed in lot 1. Eight pigs, averaging 87 pounds in weight, were placed in lot 2, and an equal number, averaging 89 pounds in weight, in lot 3. Of course, these pigs were not able to secure sufficient feed from the droppings alone to produce rapid gains, so the droppings were supplemented by corn. These pigs followed the calves throughout the test, and during the whole time those in lot 2 ate 3,715 pounds of shelled corn in addition to what undigested corn they secured from the droppings of the calves, but those in lot 3 ate only 2,953 pounds of corn. These feeds caused all the pigs to make rapid gains. Those in the second lot increased in weight 805 pounds, but the pigs in the third lot increased in weight only 689 pounds.

Small profits were made on each one of the lots of pigs, and these profits should be credited to the calves, or at least added to the total profits made in lots 2 and 3. With corn valued at 70 cents a bushel and hogs selling at 7 cents a pound, the hogs in lot 2 and 3 returned final profits of \$9.91 and \$11.32, respectively. When these profits are added to those already secured upon the calves in these two lots, the total

¹ Bureau of Animal Industry Bulletin 103.

profits on each calf were increased to \$4.97 in lot 2 and to \$4.78 in lot 3.

When the combined profits on the hogs and the calves in lots 2 and 3 are considered, it is seen that they are still smaller than the profits realized on the calves of lot 1, where cottonseed meal was the sole concentrate.

SUMMARY STATEMENTS.

1. The objects of this test were (1), to learn whether a farmer profitably can raise and fatten calves for the market by the time they are a year old, and, (2), to make a comparison of southern feeds and combinations of feeds which may be used for fattening calves during the winter months.

2. The calves were all high-grade animals, being far better than the average of the State. When the feeding test began, November 17, 1911, they averaged 376 pounds in weight and were from 6 to 8 months of age.

3. The 47 calves were divided into three lots and fed from November 17, 1911, to March 3, 1912, on the following feeds:

Lot 1. Cottonseed meal; cottonseed hulls; mixed alfalfa hay.

Lot 2. Cottonseed meal, two-thirds; corn-and-cob meal, one-third; cottonseed hulls; mixed alfalfa hay.

Lot 3. Cottonseed meal, one-third; corn-and-cob meal, two-thirds; cottonseed hulls; mixed alfalfa hay.

4. For the whole period of 107 days an average daily gain of 1.94, 1.75, and 1.59 pounds was secured in lots 1, 2, and 3, respectively.

5. For the whole period of 107 days it cost \$5.14, \$5.72, and \$6.43 to make 100 pounds of increase in live weight in lots 1, 2, and 3, respectively.

6. In the fall of 1911 the calves cost 4 cents a pound. At the end of the test they were sold on the farm for $5\frac{1}{2}$ cents a pound.

7. Each calf in lots 1, 2, and 3 netted a clear profit of \$5.40, \$4.30, and \$4.07, respectively. Hogs followed the calves that received some corn and derived some benefit from the droppings. When the profits on the hogs, as well as on the calves, are taken into consideration, each calf in lots 1, 2, and 3 netted a clear profit of \$5.40, \$4.97, and \$4.78, respectively.

8. In this particular test it did not pay, therefore, to add corn-and-cob meal to a basal ration of cottonseed meal, cottonseed hulls, and alfalfa hay if both farm-grown and purchased feeds are charged at market prices. On farms remote from markets, where a surplus of roughage and corn is produced, it would have been very profitable to feed the corn, as the farmer would have secured market prices for his roughage and corn and in addition would have made a nice profit on his calves, without the expenditure of much money for purchased feeds.

II. FATTENING BEEF CALVES ON COTTONSEED MEAL, COTTONSEED HULLS, CORN CHOP, AND CORN SILAGE.

PLAN OF WORK.

This test was conducted during the winter of 1912-13. The feeding began November 29, 1912, and closed, as far as the corn silage was concerned, March 3, 1913. The supply of corn silage was exhausted on March 3, but the calves were not ready for sale, so all were placed in one lot (they had formerly been divided into three lots for the sake of certain feed comparisons) and continued on a ration of cottonseed meal, corn chop, cottonseed hulls, and mixed alfalfa hay until April 29, 1913, when they were sold.

As these calves were of the same breeding, had been raised in the same way and from the same cows, and were fed in the same lots as those fully reported upon in Part I of this bulletin, it is not necessary to enter into a discussion of the objects of the work, of the kind of calves used, of the general plan of the work, of the method of feeding and handling, and of the shelter and lots.

THE RATIONS EMPLOYED.

Practically the only material way in which this test varied from the previous one was in the feeds used. In this test corn silage was introduced into the rations of two of the lots and was fed from November 29, 1912, to March 3, 1913, when the supply was exhausted. Each lot of 16 calves was fed the following feeds:

Lot 1. Cottonseed meal; cottonseed hulls.

Lot 2. Cottonseed meal, two-thirds; corn chop, one-third; cottonseed hulls; corn silage.

Lot 3. Cottonseed meal; cottonseed hulls; corn silage.

On March 3, 1913, they were all thrown together as one lot and continued to April 29, 1913, on the following:

Lot 4. Cottonseed meal; corn chop; cottonseed hulls; mixed hay.

Corn silage was the only new feed introduced. In the financial statements it is valued at \$3 a ton, and the other feeds are valued as on page 7.

The cottonseed meal this year was fresh and bright, analyzing from 7.5 to 7.7 per cent ammonia. The cottonseed hulls were only fair in quality. The corn chop (made by grinding shelled corn) was of excellent quality. The corn from which the chop was made was grown upon the farm and was fresh and hard. The corn silage, however, was poor in quality owing to the fact that the fodder had become too dry before it was made into silage.

DAILY RATIONS.

The test proper did not begin until November 29, 1912. Previous to this time, however, the calves were eating a small daily ration composed of cottonseed meal, cottonseed hulls, and mixed hay. The preliminary period continued 15 days, during which time the calves became accustomed to eating dry feeds.

Table 16 shows the average amount of feed eaten daily by each calf, but it should be borne in mind that these amounts were reached by gradual and careful increases.

TABLE 16.—Average daily rations (Nov. 29, 1912, to Mar. 3, 1913).

Lot No.	Number of calves.	Ration.	Average amount of feed eaten by each calf daily.
			Pounds.
1	16	(Cottonseed meal.....	2.61
		(Cottonseed hulls.....	14.13
		(Cottonseed meal, two-thirds.....	1.76
2	15	(Corn chop, one-third.....	.88
		(Cottonseed hulls.....	6.56
		(Corn silage.....	13.29
3	15	(Cottonseed meal.....	2.63
		(Cottonseed hulls.....	6.53
		(Corn silage.....	13.03

When the test began, each calf in lot 1 was eating daily a little less than 2 pounds of meal and 11 pounds of hulls. It should be remembered that the calves had been eating these feeds for 15 days before the test began. On December 12, or 14 days later, the 16 calves were raised to a daily ration of 34 pounds of cottonseed meal and 220 pounds of cottonseed hulls. On January 3 another increase in the meal was made, when the daily allowance was increased to 40 pounds. On January 14 a third increase was made, when the cottonseed meal was increased to 44 pounds. The 16 calves never ate more than 56 pounds of cottonseed meal daily, or $3\frac{1}{2}$ pounds per head per day.

If the corn silage had been of better quality, each calf would have eaten much more than 13 pounds daily. Each calf should have consumed not less than 20 pounds. No hay was used in this test; cottonseed hulls were used in place of the hay. In addition to the amount of silage eaten daily, it is seen that each calf in lots 2 and 3 ate 5.56 and 6.53 pounds, respectively, of cottonseed hulls.

WEIGHTS AND GAINS.

When the test was begun, November 29, 1912, the calves averaged from 6 to 8 months in age. As stated previously, they were out of the same cows as the calves that were used in the experiment reported in Part I, and were consequently similar in size, breeding, and qual-

ity. When the test began, the 46 calves averaged 371 pounds in weight. During the summer months the calves had run with their dams upon a reasonably good pasture. These calves, during the pasture season, became infested with cattle ticks, as the cattle grazed in a very large wooded pasture of 20,000 acres and it was a difficult matter to find all of them at each dipping period. The ticks doubtless interfered with the development of the calves. The calves that were used in the previous year's work were raised in a pasture that was almost, if not quite, free of ticks, and they were considerably heavier than the calves used in the present test.

TABLE 7.—Weights, total gains, and average daily gains (Nov. 29, 1912, to Mar. 3, 1913).

Lot No.	Number of calves.	Ration.	Average initial weight of calves.	Average final weight of calves.	Average total gain per calf.	Average daily gain per calf.
			Pounds.	Pounds.	Pounds.	Pounds.
1	16	{Cottonseed meal.....	365	505	140	1.49
		{Cottonseed hulls.....				
2	15	{Cottonseed meal, two-thirds.....	393	508	115	1.23
		{Corn chop, one-third.....				
		{Cottonseed hulls.....				
		{Corn silage.....				
3	15	{Cottonseed meal.....	357	497	140	1.49
		{Cottonseed hulls.....				
		{Corn silage.....				

It is interesting to note the effect upon the daily gains of calves when one-third of the ration of cottonseed meal is replaced by corn chop. Each calf in lot 3 ate, on the average, 2.63 pounds of cottonseed meal each day. Each calf in lot 2 consumed 1.76 pounds of cottonseed meal plus 0.88 pound of corn chop each day; that is, each pound of corn chop replaced one pound of cottonseed meal. When this was done the last column in Table 7 shows that the daily gains were reduced materially. That is, one pound of corn was not equal to one pound of cottonseed meal as a fattening ration for calves. In lot 3, where cottonseed meal, cottonseed hulls, and corn silage were fed, the calves gained at the rate of 1.49 pounds daily. In lot 2, where a part of the cottonseed meal was replaced by corn chop (one pound of corn chop replacing one pound of cottonseed meal), the average daily gains dropped to only 1.23 pounds. The calves in lot 1, where only cottonseed meal and cottonseed hulls were fed, gained at the rate of 1.49 pounds daily, or exactly the same as the daily gains recorded in lot 3.

QUANTITY AND COST OF FEED REQUIRED TO MAKE 100 POUNDS OF GAIN.

In the following statement cottonseed meal is valued at \$26 a ton, cottonseed hulls at \$7 a ton, corn silage at \$3 a ton, and corn at 70 cents a bushel. These prices represent fairly accurately the average

prices of the State. In this test, as well as in the previous one, the cost of making 100 pounds of gain was not excessive.

TABLE 8.—Quantity and cost of feed required to make 100 pounds of gain.

Lot No.	Ration.	Total feed eaten by each calf.	Average feed to make 100 pounds of gain.	Average cost of feed to make 100 pounds of gain.
		<i>Pounds.</i>	<i>Pounds.</i>	
1	Cottonseed meal.....	245	175	\$5.59
	Cottonseed hulls.....	1,329	946	
	Cottonseed meal, two-thirds.....	164	144	
2	Cottonseed hulls.....	617	536	6.09
	Corn chop, one-third.....	82	72	
	Corn silage.....	1,249	1,084	
3	Cottonseed meal.....	267	176	5.13
	Cottonseed hulls.....	614	438	
	Corn silage.....	1,225	875	

The cheapest gains were made in lot 3, where a ration of cottonseed meal, cottonseed hulls, and corn silage was used, as each 100 pounds of increase in live weight cost \$5.13. It should not be inferred immediately, however, from the above that this combination of feeds is the best of the three. The cost of the gains does not determine absolutely the final profits. Although the cost of the gains is a very important factor in determining final profits, there are other factors which must be taken into consideration as well. The final selling price of the cattle must be considered as an important factor. If expensive gains are accompanied by a proportionate increase in the final value and selling price of the cattle, the cost of the gains is a minor consideration; but if expensive gains do not increase the final selling price of the animal in proportion to the increased expense of making the gains those feeds which have caused the expensive gains should be eliminated. The most expensive gains were encountered in lot 2, where corn chop replaced a part of the cottonseed meal. In this lot it cost \$6.09 to make 100 pounds of increase in weight. Where only cottonseed meal and cottonseed hulls were fed (lot 1) each 100 pounds of gain was made at a cost of \$5.59.

When the results of lots 1 and 3 are compared it is seen that 875 pounds of corn silage saved 508 pounds of cottonseed hulls. At this rate 1 ton of corn silage saved 1,161 pounds of cottonseed hulls; when hulls are valued at \$7 a ton the corn silage, therefore, was worth for fattening these calves \$4.06 a ton.

FINANCIAL STATEMENT FOR THE SILAGE PERIOD.

The supply of silage was exhausted March 3, 1913. The calves had been in the feed lot only 94 days and they were not in condition to be sold at that date. Therefore they were all thrown together

in one lot and fed from March 3 to April 29—a period of 58 days—on a ration of cottonseed meal, corn chop, cottonseed hulls, and mixed hay.

Before the silage period ended an estimated value was placed on each lot of calves. The calves in lot 1 were in much better condition than those in either of the other two lots, so they were valued at 5½ cents a pound and the calves in lots 2 and 3 at 5¼ cents a pound. At the beginning of the experiment, November 29, 1912, they were all valued at 4½ cents a pound.

TABLE 9.—*Financial statement for silage period.*

Lot 1. Cottonseed meal, cottonseed hulls:	
To 16 calves—5,836 pounds, at 4½ cents a pound	\$262.62
To 3,925 pounds of cottonseed meal, at \$26 a ton	51.03
To 21,258 pounds of cottonseed hulls, at \$7 a ton	74.40
Total expenditures	388.05
By sale of 16 calves—8,083 pounds, at 5½ cents a pound	431.23
Total profit on lot	43.18
Average profit on each calf	2.70
Lot 2. Cottonseed meal, two-thirds; corn chop, one-third; cottonseed hulls; corn silage:	
To 15 calves—5,900 pounds, at 4½ cents a pound	\$265.50
To 2,481 pounds of cottonseed meal, at \$26 a ton	32.25
To 1,236 pounds of corn chop, at \$20 a ton	12.36
To 9,253 pounds of cottonseed hulls, at \$7 a ton	32.39
To 18,734 pounds of corn silage, at \$3 a ton	28.10
Total expenditures	370.60
By sale of 15 calves—7,628 pounds, at 5¼ cents a pound	388.46
Total profit on lot	17.86
Average profit on each calf	1.19
Lot 3. Cottonseed meal, cottonseed hulls, corn silage:	
To 15 calves—5,350 pounds, at 4½ cents a pound	240.75
To 3,702 pounds of cottonseed meal, at \$26 a ton	48.13
To 9,205 pounds of cottonseed hulls, at \$7 a ton	32.22
To 18,375 pounds of corn silage, at \$3 a ton	27.56
Total expenditures	348.66
By sale of 15 calves—7,420 pounds, at 5¼ cents a pound	377.86
Total profit on lot	29.20
Average profit on each calf	1.95

If these calves had been sold March 3, or when the supply of silage gave out, the greatest profit would have been made on the calves in lot 1, and the smallest profit in lot 2, where both corn chop and corn silage were used. But they were not ready to be sold upon

that date. As a matter of fact 6 of the best heifers were taken out of the test on March 3 and kept on the farm for future breeding purposes, so only 40 calves were in the test from March 3 to April 29.

SUBSEQUENT FINISHING PERIOD.

During the short period of 58 days, from March 3 to April 29, 1913, each one of the calves ate 204 pounds of cottonseed meal, 52 pounds of corn chop, 346 pounds of cottonseed hulls, and 371 pounds of mixed hay. (The hay, in fact, more properly should be called Johnson-grass hay, as there was very little alfalfa in it; it was valued at \$10 a ton.) During this period the calves did not make good gains—only 1.09 pounds daily. The cost to make the increase in live weight was more than normal, being \$11.31 to make 100 pounds of gain.

Notwithstanding the fact that the gains were rather small during this last period of 58 days, the calves were in reasonably good condition at the end and sold for satisfactory prices. They were sold to a buyer of Meridian, Miss., by farm weight less 3 per cent shrinkage. The 30 largest and best calves sold for 7 cents a pound. The 5 smallest ones sold for 6 cents a pound, and 5 others sold for 6½ cents a pound. Table 10 shows the results of feeding the 40 calves during the last 58 days. The initial cost—\$5.40 per hundred-weight—represents the value placed upon them at the close of the silage period, March 3.

TABLE 10.—*Financial statement for last period of 58 days.*

Lots 1, 2, and 3 combined. Cottonseed meal, corn chop, cottonseed hulls, mixed hay:

To 40 calves—21,035 pounds, at \$5.40 per cwt.....	\$1, 135. 89
To 8,156 pounds of cottonseed meal, at \$26 a ton.....	106. 03
To 2,075 pounds of corn chop, at \$20 a ton.....	25. 94
To 13,848 pounds of cottonseed hulls, at \$7 a ton.....	48. 47
To 14,847 pounds of hay, at \$10 a ton.....	74. 24
Total expenditures.....	1, 390. 57
By sale of 40 calves.....	1, 562. 92
Total profit on 40 calves for last 58 days.....	172. 35
Average profit on each calf for feeding period of last 58 days..	4. 31
Average profit on each calf for first 94 days.....	1. 96
Total profit on each calf.....	6. 27

These calves sold for good prices and finally returned excellent profits, as a clear profit of \$6.27 was realized on each animal. If they had been sold March 3, an average net profit of only \$1.96 would have been made on each calf, so it paid well to hold them longer and finish them more. The most of the profit was made during the last 58 days.

SUMMARY STATEMENT.

1. The objects of this test and the kinds of calves used were very similar to those of the previous test.

2. The whole number of 46 calves was divided into three lots and fed from November 29, 1912, to March 3, 1913, the following rations:

Lot 1. Cottonseed meal; cottonseed hulls.

Lot 2. Cottonseed meal, two-thirds; corn chop, one-third; cottonseed hulls; corn silage.

Lot 3. Cottonseed meal; cottonseed hulls; corn silage.

The supply of corn silage was exhausted by March 3, but the calves were not ready for the market, so on this date they were all thrown together as one lot and continued on:

Cottonseed meal; corn chop; cottonseed hulls; mixed hay.

3. During the silage period (November 29 to March 3) an average daily gain of 1.49, 1.23, and 1.49 pounds was secured in lots 1, 2, and 3, respectively.

4. During the silage period (November 29 to March 3) it cost \$5.59, \$6.09, and \$5.13 to make 100 pounds of increase in live weight in lots 1, 2, and 3, respectively.

5. In the fall of 1912 the calves cost $4\frac{1}{2}$ cents a pound. At the end of the silage period they were not ready to be sold and estimated values were placed upon each lot. The calves in lot 1 were valued at $5\frac{1}{2}$ cents a pound, and those in lots 2 and 3 at $5\frac{1}{4}$ cents a pound.

6. Each calf during the silage period netted a clear profit of \$2.70, \$1.19, and \$1.95 in lots 1, 2, and 3, respectively.

7. By comparing lot 1 with lot 3 it is found that one ton of corn silage saved 1,161 pounds of cottonseed hulls. If cottonseed hulls cost \$7 per ton, the corn silage, therefore, was worth \$1.06 per ton for fattening these calves.

8. This test clearly demonstrates that if corn is to replace part of a cottonseed meal ration, more than one pound of corn should be used to take the place of one pound of cottonseed meal. In other words, cottonseed meal has a greater feeding value, pound for pound, than shelled corn.

9. After the supply of silage was exhausted the calves were all fed 58 days longer on a ration composed of cottonseed meal, corn chop, cottonseed hulls, and mixed hay. They gained during this period only 1.09 pounds daily, but their value increased very materially, and at the end they sold for almost 7 cents a pound on the farm.

10. For the entire period November 29 to April 29 each calf returned a clear profit of \$6.27.

III. FATTENING CALVES ON COTTONSEED MEAL, CORN, COTTONSEED HULLS, CORN SILAGE, AND ALFALFA HAY.

TRANSFER OF WORK FROM ALABAMA TO MISSISSIPPI.

The cattle-feeding work which was conducted in Alabama in co-operation with the Experiment Station from 1904 to 1913 was transferred to the tick-free sections of Mississippi in 1914. An experimental farm was established near Canton, Miss., in the "brown loam" section of the State, and another at Abbott, Miss., near West Point, in the black-prairie section. The work which is reported herewith was conducted on the farm of Mr. Ben Walker at Abbott.

That section of Mississippi has long been recognized as a splendid live-stock section, for the prairie soils have a large lime content which induces good growth in the various clovers and alfalfa, thus furnishing good pastures and an abundance of forage. Conditions are very similar to those in western Alabama, where the former work was conducted. The land in the Mississippi pastures was not so rolling as in Alabama, but there was little difference in the type of soil and its fertility.

The object of this test was to get further information concerning the use of cottonseed meal and mixtures of cottonseed meal and corn for finishing calves for the market. This is a continuation of the work conducted in Alabama.

CALVES USED.

The calves used in the experiment were grade Shorthorn, Angus, and Red Polled, the Shorthorns predominating in numbers. They were out of grade beef cows and sired by registered bulls. All but one were raised upon the farm and ran with their dams in black-prairie pastures until just before the test was started. In size they were somewhat larger than the average Mississippi calves at weaning time, but they were of about the same size and quality as the grade beef calves found upon the good stock farms of the State. They represented the second or third cross of good beef bulls on the native Mississippi cows. They averaged 400 pounds each when taken from their dams on October 25, 1914, to be weaned, dehorned, and started on a preliminary feed. All calves were valued at 5 cents a pound on the farm without any deduction for shrinkage.

FEED LOTS AND WATER SUPPLY.

All the calves were fed in a large barn, which was open enough on the sides to permit thorough ventilation. About 50 square feet of space was allowed for each calf for lying down and exercising.

The plan of the barn was such that the calves could not have the run of the open lots. The pens were kept well bedded for the first six weeks, but there were so many steers on feed at the same time that but small amounts of bedding could be used after the sixth week. The pens were muddy and sloppy during the latter half of the feeding periods.

A water trough was in each pen and water was furnished from a deep well. Feed troughs were used for feeding the silage and grain, and the alfalfa was fed in racks over the troughs. The shattered leaves from the racks fell into the feed trough, so there was no waste of feed.

The feeding was done at 7 o'clock in the morning and 3 o'clock in the afternoon.

CHARACTER AND PRICE OF THE FEEDS.

As this experiment was for the comparison of grain rations the roughage for all lots was the same. The calves of all lots were fed about $5\frac{1}{2}$ pounds of cottonseed hulls and $3\frac{1}{2}$ pounds of alfalfa hay per head daily and given in addition all of the silage they would eat.

The cottonseed meal was about the average in quality. Analysis showed an ammonia content equal to about 7.2 per cent nitrogen. The corn was not quite as good as the average of Mississippi corn.

The cottonseed hulls were of average quality, the hulls used being good for the entire time except for a very short period when some hulls of an inferior grade were received. These were fed but a few days until good hulls could be obtained. The alfalfa hay was bright and of good quality, but contained a little Johnson grass. The corn silage contained very little grain this year and was not as good as usually is made on southern farms. Taken as a whole the feeds, with the exception of the silage, were just about the average of what are used on the stock farms of the South during average years.

The following prices were used for the feeds:

Cottonseed meal.....	per ton..	\$23.50
Cottonseed hulls	do.....	6.50
Corn-and-cob meal.....	per bushel..	.70
Corn silage.....	per ton..	3.00
Alfalfa hay.....	do.....	15.00

The prices used for cottonseed hulls and meal were the actual cost, whereas the prices used for other feeds were those used in other experiments and represented a good price for the farm-grown feeds and a profit to the farm in the production of them.

AVERAGE DAILY RATIONS BY PERIODS.

The calves of all lots had a preliminary feeding period from October 25 to November 13, during which time they were getting accustomed to the feed lots, to eating their feeds, and were recovering

from dehorning. They were therefore in condition to take readily to their feeds when started in the regular feeding period beginning November 13. The feeds for all calves were increased gradually until the end of the second 28-day period, after which time the amount of concentrates was maintained at the same figures.

The calves of each lot were given daily about the same amount of cottonseed hulls with which the concentrates were mixed and had in addition all the alfalfa hay and corn silage they would eat. The weighed hay was put in racks for the calves to eat at will and such an amount of silage was fed as the calves would clean up in one hour after feeding. It is seen that the calves receiving corn-and-cob meal did not eat quite as much alfalfa or corn silage as the calves of lot 1.

TABLE 11.—Average daily rations by 28-day periods (Nov. 14, 1914, to Apr. 5, 1915).

Lot No.	Number of calves.	Ration.	First period.	Second period.	Third period.	Fourth period.	Fifth period, 31 days.
			<i>Pounds.</i>	<i>Pounds.</i>	<i>Pounds.</i>	<i>Pounds.</i>	<i>Pounds.</i>
1	14	Cottonseed meal.....	2.8	3.4	4.0	4.0	4.0
		Cottonseed hulls.....	5.0	5.0	6.1	6.4	6.8
		Corn silage.....	11.3	11.4	13.8	14.2	14.8
		Alfalfa hay.....	3.6	3.9	3.4	2.7	3.9
2	12	Cottonseed meal.....	2.6	3.3	3.3	3.3	3.6
		Corn-and-cob meal.....	1.3	1.6	1.6	1.6	1.8
		Cottonseed hulls.....	4.9	4.7	5.7	6.4	7.1
		Corn silage.....	11.1	11.2	12.9	14.2	15.1
3	14	Alfalfa hay.....	3.3	3.6	3.1	3.3	4.4
		Cottonseed meal.....	1.4	1.8	1.9	1.9	2.0
		Corn-and-cob meal.....	2.9	3.6	3.7	3.7	3.9
		Cottonseed hulls.....	5.0	4.7	4.8	5.3	6.3
		Corn silage.....	11.2	11.1	11.5	11.8	13.9
		Alfalfa hay.....	3.5	3.6	3.2	2.7	4.1

During the first 28-day period the calves of lot 1 consumed on the average 2.8 pounds of cottonseed meal, 5 pounds of cottonseed hulls, 3.6 pounds alfalfa hay, and 11.3 pounds of silage, while the calves of lot 2 consumed 2.6 pounds of cottonseed meal and one-half as much corn-and-cob meal. Each calf in lot 3 ate 4.3 pounds of the mixture of one-third cottonseed meal and two-thirds corn-and-cob meal per head per day.

During the third period and thereafter each calf of lots 1, 2, and 3 was fed 4, 4.9, and 5.6 pounds of concentrates per day, respectively. As these calves were less than 12 months old, it seemed best not to feed them more cottonseed meal than these amounts. As the calves were never fed a heavy grain ration, the amount of roughage consumed did not decrease as the feeding progressed, but in fact increased gradually as the calves increased in weight. The amount of alfalfa hay consumed by each lot was very uniform for all lots and for all periods of the experiment. For some unknown reason the calves of all lots consumed more silage than usual during the last two periods and somewhat less hay than the average.

WEIGHTS AND GAINS.

The calves used in this experiment were raised on tick-free pastures and weighed over 400 pounds each, being somewhat heavier at weaning time than the calves used in previous tests. They were of about the same quality and breeding as the calves used in former years. They were put on a preliminary feed from October 25 to November 13, and during that time they were dehorned and the males castrated.

The calves were weighed individually on three consecutive days and an average was made of all weighings and used as the initial weight. The regular feeding period began November 13, 1914. Each lot of calves was weighed every 28 days during the test, and all calves were weighed individually at the close of the test. The calves were weighed about 10 o'clock each weigh day.

TABLE 12.—Weights and gains (Nov. 13, 1914, to Apr. 5, 1915, 143 days).

Lot No.	Ration.	Average initial weight per calf.	Average final weight per calf.	Average total gains per calf.	Average daily gains per calf.
1	Cottonseed meal.....	437	682	245	1.71
	Cottonseed hulls.....				
	Corn silage.....				
	Alfalfa hay.....				
2	Cottonseed meal, two-thirds.....	427	695	268	1.87
	Corn-and-cob meal, one-third.....				
	Cottonseed hulls.....				
	Corn silage.....				
3	Alfalfa hay.....	436	663	227	1.59
	Cottonseed meal, one-third.....				
	Corn-and-cob meal, two-thirds.....				
	Cottonseed hulls.....				
	Alfalfa hay.....				

¹ Preliminary feeding Oct. 25 to Nov. 12, inclusive.

The calves of lots 1, 2, and 3 were about the same size at the beginning of the test, averaging 437, 427, and 436 pounds, respectively. During the entire feeding period of 143 days the calves in each lot made a total gain of 245, 268, and 227 pounds per head, or an average daily gain of 1.71, 1.87, and 1.59 pounds per head. The gains for the first two lots were very satisfactory for calves of this size and quality. The gain for lot 3 was not so satisfactory, but when the daily rations of the calves are considered it is seen that the calves of lot 3 did not get as valuable a grain ration as those of lot 2, if the theory is true that one pound of cottonseed meal is equal in feeding value to two pounds of corn for fattening calves.

QUANTITY AND COST OF FEED REQUIRED TO MAKE 100 POUNDS OF GAIN.

Figures showing the amount of different kinds or combinations of feeds required to make 100 pounds of gain in weight are of most importance to prospective feeders. When a feeder knows the valua-

tion of his cattle and the available feeds, he can determine easily which feeds it will be most profitable to use, if he is given the data showing the amount of feed required to make 100 pounds of gain and the effects of such feeds on the quality of the carcass and knows the selling price of the animal.

TABLE 13.—Quantity and cost of feed required to make 100 pounds of gain (Nov. 13, 1914, to Apr. 5, 1915, 1½ days).

Lot No.	Ration.	Feed to make 100 pounds of gain.	Cost of 100 pounds gain.
		<i>Pounds.</i>	
1	Cottonseed meal.....	214	\$6.34
	Cottonseed hulls.....	346	
	Corn silage.....	774	
	Alfalfa hay.....	207	
2	Cottonseed meal, two-thirds.....	172	6.34
	Corn-and-cob meal, one-third.....	86	
	Cottonseed hulls.....	309	
	Corn silage.....	690	
3	Alfalfa hay.....	191	7.40
	Cottonseed meal, one-third.....	112	
	Corn-and-cob meal, two-thirds.....	225	
	Cottonseed hulls.....	331	
	Corn silage.....	753	
	Alfalfa hay.....	217	

There is not a great variation in the amount of roughage required to make 100 pounds of gain on the calves of the various lots. Each lot received the same roughage. The calves of lots 1, 2, and 3 required 1,327, 1,190, and 1,303 pounds of roughage, respectively, to make 100 pounds of gain in live weight. The calves of lot 1, which consumed a small amount of concentrate per day, ate more roughage than either of the other lots and likewise they made a greater gain in weight than the calves of lot 3. The calves of lots 1 and 3 required about 100 pounds more roughage to make 100 pounds of gain than the calves of lot 2.

Since all the calves received the same kind of roughage and required about the same amount of roughage to make 100 pounds of gain, a direct comparison can be made of the concentrates.

When cottonseed meal was the sole concentrate the calves (lot 1) required 214 pounds to make 100 pounds of gain. The calves of lot 2 required 172 pounds of cottonseed meal and 86 pounds of corn-and-cob meal to make the same amount of gain, whereas the calves of lot 3 required 112 pounds of cottonseed meal and 225 pounds of corn-and-cob meal.

In this test, when one-third of the cottonseed meal was replaced by an equal amount of corn-and-cob meal each pound of cottonseed meal proved to be equal to 2.05 pounds of corn-and-cob meal, and when two-thirds of the ration was made up of corn-and-cob meal each 1 pound of cottonseed meal proved the equivalent of 2.21 pounds of corn-and-cob meal. This result has been in keeping with

much of the other work done with corn and cottonseed meal in the South.

At the prices which prevailed for feeds in 1914-15, namely, cottonseed meal \$23.50 per ton, corn 70 cents per bushel, cottonseed hulls \$6.50 per ton, alfalfa hay \$15 per ton, and silage at \$3 per ton, the cost of 100 pounds of gain for lots 1, 2, and 3 was \$6.34, \$6.34, and \$7.40, respectively. This is exceedingly satisfactory, as the average for all calves was less than 7 cents per pound of gain. For mature animals fed on similar feeds the cost of each pound of gain would have been from 1½ to 4 cents more, showing the superior manner in which the calves utilize their feed. In fact, good calves are the only class of cattle that will put on gains in the feed lot at a price equal to or less than the selling price of the calves per pound.

FINANCIAL STATEMENT.

The calves used in this experiment were bought and inventoried at 5 cents a pound by farm weights without any shrinkage being deducted for fill. This price on the farm would have been equal to about 6 cents on the market, as it would have cost the producer about 1 cent a pound to cover the expense of shipping and marketing and the loss in weight. All feeds were charged at the prevailing prices named and charges were made for shipping and selling the calves. The total cost of freight, commission, feed, yardage, weighing, and insurance amounted to \$2.17 per head.

TABLE 14.—*Financial statement (Nov. 13, 1914, to Apr. 5, 1915, 143 days).*

Lot 1. Cottonseed meal, cottonseed hulls, corn silage, alfalfa hay:	
To 14 calves—6,118 pounds, at \$5 per hundredweight	\$305.90
To 7,342 pounds cottonseed meal, at \$23.50 per ton	86.27
To 11,853 pounds cottonseed hulls, at \$6.50 per ton	38.52
To 26,533 pounds corn silage, at \$3 per ton	39.80
To 7,110 pounds alfalfa hay, at \$15 per ton	53.32
To freight, yardage, commission, insurance, etc., 14 head, at \$2.175 per head	30.45
Total expenditures	554.26
By sale of 14 calves—8,740 pounds, at \$7.25 per hundredweight	633.65
Total profit on lot 1	79.39
Average profit per calf	5.67
Lot 2. Cottonseed meal two-thirds, cottonseed hulls, corn-and-cob meal one-third, corn silage, alfalfa hay:	
To 12 calves—5,124 pounds, at \$5 per hundredweight	256.20
To 5,529 pounds cottonseed meal, at \$23.50 per ton	64.96
To 2,764 pounds corn-and-cob meal, at 70 cents per bushel	27.64
To 9,940 pounds cottonseed hulls, at \$6.50 per ton	32.30
To 22,185 pounds corn silage, at \$3 per ton	33.28
To 6,155 pounds alfalfa hay, at \$15 per ton	46.16

To freight, yardage, commission, insurance, etc., 12 calves, at \$2.175 per head.....	\$26.10
Total expenditures	486.64
By sale of 10 calves—6,130 pounds, at \$7.25 per hundredweight.....	444.42
By sale of 2 calves—1,200 pounds, at \$6.50 per hundredweight.....	78.00
Total by sale of 12 calves.....	522.42
Total profit on lot 2.....	35.78
Average profit per calf.....	2.98

Lot 3. Cottonseed meal one-third, corn-and-cob meal two-thirds, cottonseed hulls, corn silage, alfalfa hay :

To 14 calves—6,111 pounds, at \$5 per hundredweight.....	305.55
To 3,756 pounds cottonseed meal, at \$23.50 per ton.....	44.13
To 7,141 pounds corn-and-cob meal, at 70 cents per bushel.....	71.41
To 10,512 pounds cottonseed hulls, at \$6.50 per ton.....	34.16
To 23,922 pounds corn silage, at \$3 per ton.....	35.88
To 6,897 pounds alfalfa hay, at \$15 per ton.....	51.73
To freight, yardage, commission, insurance, etc., 14 calves, at \$2.175 per head.....	30.45
Total expenditures	573.31
By sale of 12 calves—7,600 pounds, at \$7.25 per hundredweight.....	551.00
By sale of 2 calves—1,100 pounds, at \$6.50 per hundredweight.....	72.15
Total by sale of 14 calves.....	623.15
Total profit on lot 3.....	49.84
Average profit per calf.....	3.56

The calves of lot 1 were finished somewhat better and a little more uniformly than those of either of the other lots. The calves of lots 2 and 3 showed lack of finish due to the small grain ration fed. This was reflected in the selling price of the animals, for all calves of lot 1 sold for \$7.25 per hundred straight through, whereas there were two calves in each of the other lots which brought but \$6.50 per 100 pounds, and all the others brought \$7.25 per hundredweight.

Table 14 shows that no charge is made for the labor of feeding the calves, which was small, nor is any credit given the calves for the manure produced, nor for pork produced in lots 2 and 3. By this method the calves of lot 1 showed a net profit of \$5.67 per head; those of lot 2, \$2.98; and the ones of lot 3, \$3.56 each.

When no pork credit is allowed for lots 2 and 3, and it would have been small because of the light corn ration, it is seen that the calves of lot 1 were more profitable than those of the other lots. This is partly due to the very cheap price of cottonseed meal at that time (due to the outbreak of the war) and the comparatively high price of corn charged on the farm where it was grown. It was estimated that the corn was produced at a cost not to exceed 40 cents per bushel, and if it had been sold it would not have brought the farmer more

than 50 cents per bushel net, because of the distance from a shipping point, remoteness from market, and the bad condition of the roads over which it would have to have been handled.

When it is considered that by feeding the calves the corn, the corn silage and hay were sold through the calves at excellent prices, and more than that, a net cash profit was made, the results are considered very satisfactory.

SLAUGHTER DATA.

The calves were driven from the farm 6 miles to the loading pens.

The shrinkage in transit was 36, 57, and 29 pounds for the calves of lots 1, 2, and 3, respectively. The heavier shrink of the calves of lot 2 is unaccounted for. The average shrinkage per head for all calves was 41 pounds. Although the calves of lot 2 made the largest daily gain, they had not fattened as well as either of the other lots, and this is reflected in the manner in which they dressed out. The calves of lot 1 sold for a little more per hundredweight and dressed out slightly higher than either of the other lots.

By farm weights the calves of lot 1 killed out nearly 2½ per cent more than those of lot 2 and 0.4 per cent more than those of lot 3. By market weights the calves of all three lots killed out very uniformly, lot 1 killing out a little better than either of the other two lots. The purchaser reported that all the calves killed out well and produced nice carcasses. The calves as a whole dressed out slightly over 54 per cent by sale weights.

TABLE 15.—*Slaughter data.*

Lot No.	Ration.	Average farm weight of each calf 4-12-15.	Average market weight of each calf 4-14-15.	Average shrink in transit.	Average weight of carcass.	Percentage dressed by farm weights.	Percentage dressed by market weights.
		Pounds.	Pounds.	Pounds.	Pounds.	Per cent.	Per cent.
1	Cottonseed meal.....	660	624	36	342	51.88	54.85
	Cottonseed hulls.....						
	Corn silage.....						
	Alfalfa hay.....						
2	Cottonseed meal, two-thirds.....	668	611	57	330	49.40	54.05
	Corn-and-cob meal, one-third.....						
	Cottonseed hulls.....						
	Corn silage.....						
3	Alfalfa hay.....	651	622	29	335	51.44	53.87
	Cottonseed meal, one-third.....						
	Corn-and-cob meal, two-thirds.....						
	Cottonseed hulls.....						
	Corn silage.....						
	Alfalfa hay.....						

SUMMARY STATEMENT.

1. The object of this test was to get further information concerning the use of cottonseed meal and mixtures of cottonseed meal and corn for finishing calves for the market.

2. The average initial weights of the calves used in the test were as follows: Lot 1, 437; lot 2, 427; lot 3, 436 pounds. The final

weights were: Lot 1, 682; lot 2, 695; and lot 3, 663 pounds. The average daily gains per calf were: Lot 1, 1.71; lot 2, 1.87; and lot 3, 1.59 pounds.

3. All lots received corn silage, alfalfa hay, and cottonseed hulls as roughage. Lot 1 consumed 214 pounds of cottonseed meal for each 100 pounds gain. Lot 2 consumed 172 pounds of cottonseed meal and 86 pounds of corn-and-cob meal per 100 pounds gain. Lot 3 consumed 112 pounds cottonseed meal and 225 pounds of corn-and-cob meal for the same amount of gain.

4. The costs per 100 pounds of gain were as follows: Lot 1, \$6.34; lot 2, \$6.34; and lot 3, \$7.40. The calves of all lots made gains very cheaply.

5. The amount of roughage required to make 100 pounds of gain was greatest with lot 1 and the smallest with lot 2.

6. The average profits per head for each of the lots were as follows: Lot 1, \$5.67; lot 2, \$2.98; and lot 3, \$3.56.

7. The shrinkage of lots 1, 2, and 3 was 36, 57, and 29 pounds, respectively. The heavy shrinkage of lot 2 can not be explained.

8. By market weights the calves dressed out as follows: Lot 1, 54.85; lot 2, 54.05; lot 3, 53.87 per cent.

9. There were no pigs following the calves of lots 2 and 3. Under these conditions it did not pay as well to feed a mixture of cottonseed meal and corn-and-cob meal as it did to feed cottonseed meal as the sole concentrate.

IV. FATTENING CALVES ON COTTONSEED MEAL, CORN, CORN SILAGE, AND ALFALFA.

PLAN OF WORK.

The calf-feeding work for the winter of 1915-16 was conducted on the farm of Mr. Ben Walker near West Point, Miss., in the black-prairie section of the State. As the lots, shelter, and watering facilities have been described in connection with the previous year's work it is needless to repeat here. The only difference in conditions was that the calf pens were concreted during the summer months in order that the calves would not be forced to stand in the mud as they had during the latter part of the experiment of the previous year.

The calves were of about the same grade as those of the previous year, as half of them were raised on the farm and the other half bought from a neighboring farmer for 5 cents per pound. The majority of the calves were Shorthorns and Herefords, but a few Angus calves also were included. All the calves had run with their dams until about two weeks before the experiment started, when the

purchased calves were weaned, dehorned, marked, and turned into an alfalfa field until the experiment was started. The home-raised calves were weaned, dehorned, and marked just a few days before the experiment was to start. All the calves had been dropped in the spring and were from 7 to 8 months old when weaned.

The calves were weighed individually on November 11, and again on the 12th, on which date they were divided into three similar lots and started on feed.

OBJECTS OF THE WORK.

In the Alabama experiments the calves were given small rations of grain for comparatively short periods. They made satisfactory gains and were in good killing order but were not well finished at the close of the tests. In this test it was decided to feed the calves for a longer period and to give them a heavier grain ration in order to have them well finished before they were sold.

The objects of this test were:

1. To see if good grade calves such as can be raised easily in Mississippi can be finished for the market economically and profitably.
2. To make a comparative study of the value of cottonseed meal alone, a combination of cottonseed meal and shelled corn, and shelled corn alone, as concentrated feeds to be used in finishing calves that were to be fed silage as the principal roughage, with a small amount of alfalfa hay.
3. To determine approximately how much manure could be saved by feeding calves on a concrete floor under shelter.

CHARACTER AND PRICES OF THE FEEDS USED.

As this test was a comparison of grain feeds, the same kind of roughage was fed to all three lots. Feeders generally have the impression that cattle which are being fattened will do somewhat better if they are given a small amount of some palatable hay when they are fed corn silage as the chief roughage. For this reason the calves of all lots were given about $4\frac{1}{2}$ pounds of alfalfa hay per day in addition to all of the corn silage they would eat.

The cottonseed meal used was bright and of good quality, analyzing from $7\frac{1}{2}$ to 8 per cent of ammonia. The corn was of good quality, being well matured and sound. The silage was of good quality, having been cut at the proper stage and carrying considerable grain. The corn probably would have yielded 45 bushels to the acre. The alfalfa was of rather low grade, as it had been damaged by heavy dews.

The feeds were charged at the following prices:

Cottonseed meal.....	per ton..	\$27. 00
Corn	per bushel..	. 70
Corn silage.....	per ton..	3. 00
Alfalfa hay.....	do.....	15. 00

AVERAGE DAILY RATIONS.

As all the calves were accustomed to alfalfa they were started on about 6 pounds of alfalfa hay and about 15 pounds of silage per day. The silage was increased rapidly as the calves became accustomed to it until at the end of two weeks they were given all they would clean up within one hour after feeding. As the calves were to be fed a long period they were started on a small amount of grain and this was very gradually increased until the fourth month after which they were given the maximum amount of grain until the close of the test.

It is a well-known fact that cattle to be fed for a long period will make almost as large gains and much more economical gains if they are fed a medium grain ration with all the good roughage they will eat for first part of the feeding period, and then given a heavy grain ration during the latter part of the period. This method was followed.

Table 16 shows the average amount of feed consumed daily by each of the calves in lots 1, 2, and 3 for each 28-day period they were fed.

TABLE 16.—Average daily rations by 28-day periods, 1915-16.

Lot No.	Ration.	First period.	Second period.	Third period.	Fourth period.	Fifth period.	Sixth period (16 days).	Average for entire of 156 days.
		<i>Pounds.</i>	<i>Pounds.</i>	<i>Pounds.</i>	<i>Pounds.</i>	<i>Pounds.</i>	<i>Pounds.</i>	<i>Pounds.</i>
1	Cottonseed meal.....	2.2	2.7	3.5	4.3	5.0	5.0	3.69
	Corn silage.....	16.8	22.7	23.8	25.3	23.7	26.7	22.87
	Alfalfa hay.....	5.9	5.8	4.0	4.0	4.0	4.0	4.65
2	Cottonseed meal.....	1.00	1.2	1.3	1.6	2.0	2.0	1.49
	Shelled corn.....	4.1	4.8	5.4	6.6	8.0	8.0	6.01
	Corn silage.....	14.7	18.3	18.3	18.9	16.2	18.6	17.43
3	Alfalfa hay.....	5.8	5.4	4.0	4.0	3.9	4.0	4.57
	Shelled corn.....	6.0	7.1	8.1	9.7	11.1	12.2	8.78
	Corn silage.....	13.6	13.7	15.6	14.3	12.1	13.3	13.80
	Alfalfa hay.....	5.5	5.6	4.0	4.0	3.6	4.0	4.49

During the first 28-day period each calf in lot 1 consumed 2.2 pounds of cottonseed meal, 2.7 pounds for the second period, and this amount was increased gradually as the feeding progressed until during the fifth and sixth periods the calves were on full feed, eating 5 pounds of cottonseed meal per head per day. The calves consumed 5.9 pounds of alfalfa and 16.8 pounds of corn silage per head per day the first period, but the hay was decreased after the second period to

4 pounds per head daily, and all of the corn silage was given that the calves would eat. This increased as the amount of hay was reduced, until during the last three periods each calf ate about 25 pounds of silage daily.

The concentrated feeds of the other two lots were increased in about the same manner. When the calves of lot 2 were on full feed they consumed 2 pounds of cottonseed meal and 8 pounds of shelled corn per head daily, whereas each calf in lot 3 received 12 pounds of shelled corn each day. The amount of silage consumed by the calves of lot 2 was about 7 pounds less than that consumed by the calves of lot 1. The calves of lot 3, which were fed on shelled corn alone as the concentrate, consumed but about half as much silage each day during the last two periods as the calves which were fed cottonseed meal. The amount of alfalfa hay was the same for all of the lots.

The last column of Table 16 shows the average amount of feed consumed daily by each calf for the entire feeding period of 156 days.

Table 17 shows the average initial weight, the average final weight, the average gain per calf, and average daily gain per calf for the entire feeding period.

TABLE 17.—*Total and daily gains (Nov. 12, 1915, to Apr. 16, 1916, 156 days).*

Lot No.	Ration.	Average initial weight per calf.	Average final weight per calf.	Average total gains per calf.	Average daily gains per calf.
		Pounds.	Pounds.	Pounds.	Pounds.
1	Cottonseed meal.....	430	701	271	1.74
	Corn silage.....				
	Alfalfa hay.....				
2	Cottonseed meal.....	430	695	265	1.7
	Shelled corn.....				
	Corn silage.....				
3	Alfalfa hay.....	434	714	280	1.8
	Shelled corn.....				
	Corn silage.....				

The average weights of the calves of the three lots were very uniform at the beginning of the test, being 430, 430, and 434 pounds for lots 1, 2, and 3, respectively. The average total gain per calf for the entire period was 271, 265, and 280 pounds, or a daily gain of 1.74, 1.70, and 1.80 pounds per head, respectively. These gains were very satisfactory for a long feeding period and they indicate that all the calves did well.

The calves of lot 1 were inclined to grow and did not fatten as rapidly as the calves of either of the other two lots. The calves of lot 3 were the fattest of the three lots, although there was not a great deal of difference between the calves of lots 2 and 3.

QUANTITY AND COST OF FEED TO MAKE 100 POUNDS OF GAIN.

The most important data in any feeding experiment are those relating to the daily ration, the rate of gain made by the animals, the amount of feed which is required to make 100 pounds of gain in weight, and the difference in selling price which results from the different methods of feeding. With these figures any prospective feeder can determine fairly accurately what feeds he had better use in fattening his cattle, how much he will need, and the gains he may expect; and knowing the cost of his cattle and feeds and about what the finished cattle will sell for he can approximate the profit or loss which may result from fattening his stock.

In the past farmers and stockmen have paid too little attention to these figures and laid too much stress upon the financial outcome of the special test to get the most good out of the experimental work.

Table 18 shows the amount of feed required to produce 100 pounds of gain in weight on the calves and also the comparative cost of 100 pounds of gain.

TABLE 18.—Quantity and cost of feed required to make 100 pounds of gain, and selling price of calves (Nov. 12, 1915, to Apr. 12, 1916, 156 days).

Lot No.	Ration.	Feed to make 100 pounds of gain.	Cost of 100 pounds gain. ¹	Selling price of calves per 100 pounds.
		<i>Pounds.</i>		
1	Cottonseed meal.....	213	\$6.86	\$8.17
	Corn silage.....	1,318		
	Alfalfa.....	268		
2	Cottonseed meal.....	88	9.05	8.58
	Shelled corn.....	353		
	Corn silage.....	1,025		
3	Alfalfa hay.....	269	9.11	8.66
	Shelled corn.....	489		
	Corn silage.....	769		
	Alfalfa hay.....	250		

¹ Prices of feeds used: Cottonseed meal, \$27 per ton; corn, 70 cents per bushel; corn silage, \$3 per ton; alfalfa hay, \$15 per ton.

The calves in all three lots received the same kind of roughage, but ate varying amounts, dependent upon their appetites after consuming their grain. The daily gain of the calves in all lots was fairly uniform, but the amount of roughage consumed varied considerably. This variation is reflected in the amount of roughage required to make 100 pounds of gain.

The amount of feed required to make 100 pounds of gain is seen to be 213 pounds of cottonseed meal, 1,318 pounds of silage, and 268 pounds of alfalfa hay for lot 1; 88 pounds of cottonseed meal, 353 pounds of shelled corn, 1,025 pounds of silage, and 269 pounds of alfalfa for lot 2; and 489 pounds of shelled corn, 769 pounds of silage, and 250 pounds of alfalfa for lot 3.

The comparative cost of 100 pounds of gain for lots 1, 2, and 3 are \$6.86, \$9.05, and \$9.14, respectively. The calves of lot 1 are seen to have required a very small amount of cottonseed meal and a comparatively large amount of cheap roughage to make 100 pounds of gain, while the opposite is true of the calves of lot 3, which received shelled corn as a concentrate. The calves of lot 3 required more than twice as much grain to make 100 pounds of gain, somewhat less alfalfa, and only a little more than half as much silage. This resulted in more expensive gains for the calves receiving corn. The amount of feed required to make 100 pounds of gain on the calves is considerably smaller than the amount required to put the same amount of gain on mature cattle. In fact it is seldom possible to make gains on any class of cattle in the dry lot, except calves, at a smaller cost than the selling price of the animals. This was done with the calves of lot 1.

The exclusive use of cottonseed meal as a concentrate for feeding calves has resulted invariably in good daily gains and very economical gains, but at the same time there has been a tendency for such calves to grow more and fatten less than is desirable while fattening. This has resulted in such calves selling for somewhat less than corn-fed calves, as shown in Table 18. The difference in selling price is often great enough almost to overcome the difference in the cost of production. There was a difference of 49 cents per 100 pounds in the selling price of the calves of lots 1 and 3 and a difference of 41 cents per hundredweight in the selling price of the calves of lots 1 and 2.

Strictly prime calves can not be made by feeding cottonseed meal as the sole concentrate, and though it is not always most profitable to put the maximum finish on calves it is usually more profitable to have them well finished than half fat. It is more frequently the case that extra finish on calves pays better than it does on steers of two years or older.

FINANCIAL STATEMENT.

Although any financial statement that is made is more or less unsatisfactory because there are so many variations from year to year in the prices of feeds, selling prices of animals, and margin of profit that the financial outcome may be reversed completely if any very radical change is made in any one of these factors, such a statement usually is desired by the reader and is of some value for comparative purposes.

One-half the calves used in this experiment were purchased for 5 cents a pound, pasture weights, without any shrink, so all the calves are charged in at that price. At this price the farmers made a profit raising them, as the cows were worth but about \$45 each and

the cost of wintering cows and pasturing them in that section of Mississippi is comparatively small. They were shipped to the St. Louis market, where they were sold. All the charges for shipping and selling are included in Table 19 with the other charges:

Table 19.—Financial Statement (Nov. 12, 1915, to Apr. 16, 1916, 156 days).

Lot 1. Cottonseed meal, corn silage, alfalfa hay:	
To 15 calves—6,450 pounds, at \$5 per hundredweight	\$322.50
To 8,636½ pounds cottonseed meal, at \$27 per ton	\$116.59
To 53,522 pounds corn silage, at \$3 per ton	80.28
To 10,890 pounds alfalfa hay, at \$15 per ton	81.68
Total cost of feed	278.55
To freight charges	29.52
To commission	7.03
To yardage, hay, etc	4.83
Total miscellaneous expenditures	41.38
Total expenditures	\$642.43
By sale of 15 calves—9,790 pounds, at \$8.168 per hundredweight	799.65
Total net profit on lot 1	157.22
Average net profit per calf	10.48
Lot 2. Cottonseed meal, shelled corn, corn silage, alfalfa hay:	
To 14 calves—6,017½ pounds, at \$5 per hundredweight	\$300.88
To 3,256 pounds cottonseed meal, at \$27 per ton	\$43.96
To 13,116 pounds shelled corn, at 70 cents per bushel	163.95
To 38,076 pounds corn silage, at \$3 per ton	57.11
To 9,986 pounds alfalfa hay, at \$15 per ton	74.90
Total cost of feed	339.92
To freight charges	27.55
To commission	6.56
To yardage, hay, etc	4.51
Total miscellaneous expenditures	38.62
Total expenditures	679.42
By sale of 14 calves—9,320 pounds, at \$8.578 per hundredweight	799.35
Total net profit on lot 2	119.93
Average net profit per calf	8.57
Lot 3. Shelled corn, corn silage, alfalfa hay:	
To 15 calves—6,505 pounds, at \$5 per hundredweight	\$325.25
To 20,547 pounds shelled corn (366.9 bushels), at 70 cents per bushel	\$256.84
To 32,289 pounds corn silage, at \$3 per ton	48.43
To 10,515 pounds alfalfa hay, at \$15 per ton	78.86
Total cost of feed	384.13

To freight charges-----	\$29.52
To commission-----	7.03
To yardage, hay, etc-----	4.83
Total miscellaneous expenditures-----	\$41.38
Total expenditures-----	750.76
By sale of 15 calves—10.170 pounds, at \$8.662 per hundredweight--	880.93
Total net profit on lot 3-----	130.17
Average net profit per calf-----	8.68

In Table 19 no credit is given for the pork made by hogs following the calves of lots 2 and 3. Without considering this, exceedingly satisfactory profits were made on all the calves. The calves of lot 1 made a profit of \$10.48 per head, those of lot 2 made \$8.57 each, and the calves of lot 3 realized a net profit of \$8.68, after paying the farmer an exceedingly good price for his corn, corn silage, and alfalfa hay.

Hogs were put in lots 2 and 3 to follow the calves, but owing to cholera breaking out on one part of the farm some of the fattest shoats were sold. Later some pigs and sows were permitted to follow the calves, but with existing conditions accurate records could not be kept of the gains made by them. It is estimated, however, that there should have been a pork credit of at least \$3 per calf for each of the calves of lot 3.

If the pork credit had been but \$2 per calf in lot 3, that would have meant that the calves that were fed a ration of shelled corn alone had paid the farmer 70 cents a bushel for the corn produced on the farm as well as market prices for all the roughage consumed, and in addition made as much profit as the calves that had been fed exclusively on cottonseed meal costing but \$27 per ton. Furthermore it indicates that the diversified farmer of the South, with plenty of nutritious feeds, as silage, alfalfa, clover or cowpea hay, and corn, can finish out good calves without making cash expenditures for any purchased feeds. The farmer who does not have corn to feed but has good roughage, such as silage and hay, can feel sure that he can make good gains and economical gains by feeding cottonseed meal as the sole concentrate, but he can not get the calves quite as well finished, because of their tendency to grow when fed a heavy protein ration.

RECORD OF MANURE PRODUCED.

The calves were kept in pens having concrete floors under shelter, and the pens were scraped out daily and the manure weighed. No bedding was used, so there was some waste of liquid manure. Table 20 shows the amount of manure saved from the calves of each pen or lot:

TABLE 20.—*Manure yields (Nov. 12, 1915, to Apr. 16, 1916, 156 days).*

	Pounds.
Lot 1. Total yield.....	68,235
Average per calf.....	4,549
Average per calf daily.....	29.16
Lot 2. Total yield.....	60,090
Average per calf.....	4,083
Average per calf daily.....	26.17
Lot 3. Total yield.....	49,830
Average per calf.....	3,322
Average per calf daily.....	21.29

It is seen that for the 156-day period there were saved from each calf in lot 1, 29.16 pounds of manure daily, while 26.17 pounds per head were saved from lot 2, and 21.29 pounds daily from each calf of lot 3.

No definite reason can be given for the calves of lot 1 producing more manure than those of the other lots. Can it be possible that the high protein ration caused the calves to drink more water, thereby causing more liquid manure to be voided? The fact remains that the average amount of manure produced per day by such calves was about 27 pounds per head.

SLAUGHTER DATA.

In shipping to the St. Louis market the calves were in transit 26 hours. The average net shrinkage per head was 48, 29, and 36 pounds for lots 1, 2, and 3, respectively, amounting to 6.8, 4.2, and 5.0 per cent of their live weights. The average shrinkage on calves of this weight in transit 26 hours usually ranges from 5 to 7½ per cent of their live weight. It is seen that the shrinkage here was a little less than average. The difference in shrinkage between the calves of the three lots can not be accounted for, as they were handled exactly alike. It is to be expected that the calves of lot 1 would shrink somewhat more than the other calves because they were not as fat and had been consuming a greater amount of roughage per day, but the difference was quite large.

TABLE 21.—*Slaughter data.*

Lot No.	Ration.	Average farm weight per calf 4-16-16.	Average market weight per calf 4-19-16.	Average shrinkage in transit.	Percentage of shrinkage.	Average weight of carcass.	Percentage dressed by farm weights.	Percentage dressed by market weights. ¹
		Pounds.	Pounds.	Pounds.	Per cent.	Pounds.	Per cent.	Pounds.
1	Cottonseed meal.....	701	653	48	6.8	363	49.3	54.4
	Corn silage.....							
	Alfalfa hay.....							
2	Cottonseed meal.....	695	666	29	4.2	380	53.7	56.0
	Shelled corn.....							
	Corn silage.....							
	Alfalfa hay.....	714	678	36	5.0	387	53.1	55.9
3	Shelled corn.....							
	Corn silage.....							
	Alfalfa hay.....							

¹ Three calves, Nos. 22, 17, and 8, weighing 450, 500, and 480 pounds, respectively, were sold from lots 1, 2, and 3, as stockers. Thus slaughter data were obtained on the lots from 14, 13, and 14, calves, respectively. The farm weights of Nos. 22, 17, and 8 were 483, 520, and 515 pounds, respectively.

The carcasses of the calves of lot 1 did not show as much fat or finish as those of lots 2 and 3. No difference could be seen between the carcasses of lots 2 and 3, as they were well finished. By the farm weights the calves of lots 1, 2, and 3 dressed out 49.3, 53.7, and 53.1 per cent, respectively. By the market weights the calves of lot 1 dressed out 54.4 per cent; those of lot 2, 56 per cent; and the calves of lot 3, 55.9 per cent of their live weight.

SUMMARY STATEMENT.

1. The objects of this test were (1) to see if the feeding of heavy grain rations to calves until they were well finished would be profitable; (2) to make a comparative study of the value of cottonseed meal alone, a combination of cottonseed meal and shelled corn, and shelled corn alone, to be fed with a ration of silage with a small allowance of alfalfa hay; and (3) to determine approximately how much manure can be saved by feeding calves on a concrete floor.

2. The calves were good grade calves having from two to three crosses of beef blood on original scrub stock. They were from 6 to 8 months of age and weighed 271, 265, and 280 pounds for lots 1, 2, and 3, respectively, at weaning time, when the experiment began.

3. When on full feed the calves were eating the following ration per head per day:

	Pounds.
Lot 1.—Cottonseed meal	5.0
Corn silage	26.7
Alfalfa hay	4.0
Lot 2.—Cottonseed meal	2.0
Shelled corn	8.0
Corn silage	18.6
Alfalfa	4.0
Lot 3.—Shelled corn	12.0
Corn silage	13.3
Alfalfa	4.0

The calves that consumed a heavy grain ration consumed a smaller grain ration and vice versa.

4. The calves were fed for 156 days and during that entire time made a daily gain of 1.74, 1.7, and 1.8 for lots 1, 2, and 3, respectively. This is a good gain for calves for a long feeding period.

5. The cost of making 100 pounds of gain for each of the three lots was \$8.17, \$8.58, and \$8.66, respectively.

6. When no pork credit is allowed the calves of lots 2 and 3 the average profit per head was: Lot 1, \$10.48; lot 2, \$8.57; and lot 3, \$8.68. It is estimated that the pork produced was worth about \$3 per calf, which would make the corn feeding slightly more profitable than feeding cottonseed meal alone.

7. The calves of lots 1, 2, and 3 produced 29.2, 26.2, and 21.3 pounds of manure per head per day. No bedding was used and the manure was scraped up and weighed daily. Some of the liquid was lost.

8. During shipment the calves of lots 1, 2, and 3 shrank 48, 29, and 36 pounds, respectively, or 6.8, 4.2, and 5.0 per cent of their live weight.

9. The calves dressed out 54.4, 56.0, and 55.9 per cent of marketable meat. These percentages indicate that there was practically no difference in the fatness of the calves of lots 2 and 3, but both lots were much fatter than the calves of lot 1.

V. FATTENING LATE (SHORT-AGED) CALVES FOR MARKET.

HANDLING OF LATE CALVES.

In the foregoing parts of this bulletin are discussed various methods of fattening calves for the market during winter months. Experience has taught many feeders that a good growthy calf 6 months or more of age goes on feed and is fed much more satisfactorily than calves of a younger age. A calf 6 to 8 months old when put on feed does not seem to go off feed so easily as a younger calf, and as a result usually makes a larger and more uniform gain in weight from month to month than calves from 3 to 5 months of age.

In the South, where cattle usually are handled as a side line on the farm, the calves usually are dropped any time from January to August and some even later. Even on the good stock farms, where the time of breeding the cows is regulated as far as possible, it is seldom that all the calves are born during the early spring months; there are always some late or short-aged calves if the bull is kept with the cows until most of them get with calf.

How to handle these calves has long been a problem. When calves are selected for feeding purposes in the fall, the late ones always are cut back because of their age and size. Many of the younger ones are permitted to nurse their dams during the winter months, are weaned in the spring, and put on pasture to be grown out as yearlings or two-year-olds.

In the fall of 1915 there were a large number of such calves on the farm at Abbott, Miss., where the cooperative cattle-feeding work was being conducted jointly by the Bureau of Animal Industry and the Mississippi Agricultural College. It was decided to let these calves nurse their dams during the winter, maintaining the dams on a ration of coarse hay, silage, and a small amount of cottonseed meal,

and then wean the calves in the spring and feed them out on pasture for the fall market. In case the calves would not become sufficiently fat and heavy on pasture, they were to be finished in the dry lot the following fall.

PLAN AND OBJECT OF THE WORK.

The objects of the work were as follows:

1. To determine if short-aged or late summer calves could be fed out or finished economically and profitably the following year.

2. To learn whether cottonseed cake or a mixture of cottonseed cake and shelled corn was most satisfactory and profitable as a grain ration for fattening calves on grass and in the dry lot.

The dams of the calves ran in the stalk fields and meadows of the plantation during most of the winter, but during the latter part they were fed some rough hay, silage, and a small amount of either cottonseed or cottonseed cake. The calves ran with their dams during this period and picked up some feed. They were from 6 to 8 months old in the spring when they were taken from their dams, weaned, divided into two lots as nearly equal in quality, breeding, and size as it was possible to get them, and put on pasture, where they were to be given a supplemental grain ration once a day.

The calves were principally grade Shorthorns and Red Polls, although a few calves of other breeding were among them.

Water was obtained from pools or ponds in the pasture, and these became very muddy and foul from the calves standing in them. This is the common method of watering cattle in the prairie region of Mississippi and Alabama.

CHARACTER AND PRICES OF FEEDS USED.

The two lots of calves were grazed on pastures as nearly uniform, with respect to the character of grasses, amount of grazing, character of soil and water, as it was possible to get. The pastures used were native unimproved prairie pastures with some relatively unimportant native grasses and Lespedeza or Japan clover growing on them. The Lespedeza furnished the principal grazing, although there was some crab grass and foxtail which was grazed to a certain extent. The pastures had many bare places where no plants grew. Good improved pastures could be made on such land by plowing, disking, and planting to good grasses and legumes, but in their native state they were relatively poor prairie pastures. About 4 acres were allowed for each calf.

The summer of 1916 was an unusually droughty one, and as a result the pastures were poor and short all summer. There was no

rain on the pastures from July 25 to October 30, and as a result the calves had to be taken off pasture on October 31 and put in the feed lot because of scarcity of water and shortness of grass.

The cottonseed cake which was fed while the calves were on pasture contained about 38 per cent protein and was bright in color. It was a medium grade of cake. The corn was good sound corn, free from weevils. Cottonseed cake cost \$30.50 per ton, and corn was valued at 80 cents per bushel. Pasture was charged at the rate of 50 cents per head for each 28-day period.

METHODS OF FEEDING AND HANDLING THE CALVES.

The calves were fed once each day, between 5 and 6 o'clock in the afternoon. They were numbered by means of metal tags on neck straps. The cottonseed cake and the mixture of one-third cottonseed cake and two-thirds shelled corn were fed in troughs located at a convenient place in each pasture. Salt was given the calves once a week.

The calves of lot 1 were started on 1 pound of cottonseed cake per day and this amount gradually increased until at the end of the second 28-day period they were eating 3 pounds per day, and at the end of the third period they were eating $4\frac{1}{2}$ pounds per head per day. They were fed this amount for the rest of the summer.

The calves of lot 2 were started on one-half pound of cottonseed meal and 1 pound of corn per head daily. This was increased gradually until at the end of the second period they were eating 1 pound of cottonseed meal and 2 pounds of corn. By the end of the third 28-day period they were eating 3 pounds of cottonseed meal and 6 pounds of shelled corn per head daily. This amount was fed until the end of the grazing season, October 30, 1916.

Each of the calves was weighed individually three days in succession at the beginning of the experiment and the average taken as the initial weight. Each lot of calves was weighed each 28 days thereafter as a whole, and individual weights again were taken at the end of the grazing season.

RESULTS OF THE SUMMER FEEDING.

Table 23 shows the results of the calf feeding for the entire summer period, May 5 to October 30, 1916, inclusive.

There were 25 calves in each lot at the beginning of the experiment, but one calf in lot 2 died of blackleg, leaving but 24 in that lot. The calves of each lot were fed from May 5 to October 30, inclusive, or 179 days. The average weight of the calves of lot 1 on May 5 was 333 pounds and the average weight of those of lot 2 was 340 pounds. During the summer each calf in lot 1 gained 252 pounds and each calf in lot 2 gained 293 pounds. The average daily gain of lots 1 and 2 was 1.41 and 1.63 pounds per head, respectively.

These gains seem rather small for calves that were fed as liberally as these, but when the exceedingly drouthy summer with the resulting poor pastures is considered the calves did very well. The calves of lot 2, which were fed a heavier grain ration than those of lot 1, made the larger gains.

TABLE 23.—*Calf feeding during the summer of 1916 (May 5 to Oct. 30, 179 days).*

Item.	Lot 1: pasture and cottonseed cake.	Lot 2: pasture and one-third cottonseed cake; two-thirds shelled corn.
Number of calves.....	25	24
Length of feeding period.....days..	179	179
Average initial weight of calves, May 5.....pounds..	333	340
Average final weight of calves, October 30.....do.....	585	633
Average total gain per head.....do.....	252	293
Average daily gain per head.....do.....	1.41	1.63
Amount of feed required to make 100 pounds of gain { Cottonseed cake.....pounds..	247	126
Shelled corn.....do.....		250
Cost of making 100 pounds gain, pasture included.....	\$5.04	\$6.58
Cost of calves per hundredweight, May 5.....	5.00	5.00
Cost of calves per head, May 5.....	16.65	17.00
Cost of feed per head for entire summer.....	9.50	16.08
Cost of pasture per head for entire summer.....	3.20	3.20
Total cost per calf on Oct. 30, 1916.....	29.37	36.27
Average cost per hundredweight in fall, October 30.....	5.02	5.73

It is seen that the calves of lot 1 required 247 pounds of cottonseed cake in addition to grass to make 100 pounds of gain in weight, and the calves of lot 2 required 126 pounds of cottonseed cake and 250 pounds of shelled corn for producing 100 pounds of gain in weight. When the feeds are charged at market prices and pasture at 50 cents per head for each 28-day period it cost \$5.04 and \$6.58 to make 100 pounds of gain in live weight on the calves of lots 1 and 2, respectively.

The calves were valued at 5 cents a pound on May 5, when the experiment began, the cost per head at that time being \$16.65 for lot 1 and \$17 for lot 2. The cost of the concentrate fed during the summer was \$9.50 per calf for lot 1 and \$16.08 per head for lot 2. There was a pasturage charge of \$3.20 per head for the calves of each lot for the summer. The total cost per calf in the fall of the year (October 30, 1916) was \$29.37 for lot 1 and \$36.27 for lot 2. The average cost per hundredweight in the fall was \$5.02 for the calves of lot 1 and \$5.73 for the calves of lot 2.

At this time the calves of lot 2 were in much better shape than those of lot 1, but the calves of each lot had been growing considerably and were not well enough finished to be marketed at this time. As they were not fat enough for market on October 30 and the grass was very short, it was decided to put the calves in the dry lot and feed them corn silage for roughage and continue the grain ration the same as when the calves were on pasture until they were finished.

METHOD OF HANDLING THE CALVES.

The calves were weighed up on October 30 and transferred to the barn, where they were started on feed October 31, 1916. The calves of each lot were fed in pens in a large barn which was open enough on the sides and ends so there was plenty of ventilation at all times. The pens were concreted, so the calves were not in the mud. Fresh water from a deep well was kept before the calves at all times. The silage was fed in troughs and the grain ration mixed with it. The silage was of good quality and was eaten readily by the calves. Feeding was done at 7 a. m. and 3.30 p. m. each day. The calves were weighed each 28 days while on feed.

AVERAGE DAILY RATINGS.

Table 24 shows the daily ratings per calf by 28-day periods

TABLE 24.—Average daily ratings by 28-day periods (Oct. 31, 1916, to Jan. 5, 1917, 67 days).

Lot No.	Number of calves.	Ration.	First period.	Second period.	Third period (11 days).	Total amount of feed eaten per head.	Average daily ration for entire period.
			<i>Pounds.</i>	<i>Pounds.</i>	<i>Pounds.</i>	<i>Pounds.</i>	<i>Pounds.</i>
1	25	{Cottonseed meal.....	4.5	4.5	4.5	299	4.5
		{Corn silage.....	35.8	37.8	37.5	2,460	37.0
2	24	{Cottonseed meal.....	3.0	3.0	3.0	199	3.0
		{Shelled corn.....	6.0	6.0	6.0	399	6.0
		{Corn silage.....	27.6	30.3	30.0	1,938	29.1

During the first 28 days of the feeding period the calves of lot 1 consumed 35.8 pounds of silage per head per day, and those of lot 2 consumed 27.6 pounds.

The grain ration for each calf of lot 1 was 4.5 pounds of cottonseed meal per day for the entire period, and each calf in lot 2 was fed 3 pounds of cottonseed meal and 6 pounds of corn daily.

For the remainder of the feeding period, the calves of lot 1 ate about 37.5 pounds of silage per head per day, and those of lot 2 about 30 pounds each. The average daily ration for the entire period was 4.5 pounds of cottonseed meal and 37 pounds of silage for lot 1, and 3 pounds cottonseed meal, 6 pounds shelled corn, and 29.1 pounds of silage for lot 2.

TOTAL AND DAILY GAINS.

The total and the daily gains made by each calf are shown in table 25.

At the beginning of the winter feeding the calves of lot 1 averaged 585 pounds in weight. During the 67 days the calves were on feed the calves of lot 1 receiving cottonseed meal gained 100 pounds each,

or an average daily gain per calf of 1.49 pounds. The calves of lot 2, averaging 633 pounds, gained 102 pounds, or 1.52 pounds per head per day. These gains were not large, but it must be remembered that the calves had been on feed some time before being put in dry lot. They fattened much more rapidly than the gains would indicate, and at the end of the feeding period were quite fat.

TABLE 25.—*Total and daily gains (Oct. 31, 1916, to Jan. 5, 1917, 67 days).*

Lot No.	Number of calves.	Ration.	Average initial weight per head.	Average final weight per head.	Total average gain per head.	Average daily gain per head.
			<i>Pounds.</i>	<i>Pounds.</i>	<i>Pounds.</i>	<i>Pounds.</i>
1	25	Cottonseed meal.....	585	685	100	1.49
		Silage.....				
2	24	Cottonseed meal.....	633	735	102	1.52
		Shelled corn.....				
		Corn silage.....				

AMOUNT AND COST OF FEED REQUIRED TO MAKE 100 POUNDS OF GAIN.

Table 26 shows the total gain, the total amount of feed consumed per calf, the amount of feed required to make 100 pounds of gain, and the cost of 100 pounds of gain with feeds charged at market prices.

TABLE 26.—*Amount and cost of feed required to produce 100 pounds of gain (Oct. 31, 1916, to Jan. 5, 1917, 67 days).*

Lot No.	Number of calves.	Ration.	Total amount of feed eaten per head.	Average total gains per head.	Feed required to make 100 pounds of gain.	Cost of feed to make 100 pounds of gain.
			<i>Pounds.</i>	<i>Pounds.</i>	<i>Pounds.</i>	
1	25	Cottonseed meal.....	299	100	299	\$9.82
		Silage.....	2,460	.....	2,460	
2	24	Cottonseed meal.....	199	102	195.1	12.44
		Shelled corn.....	399	.....	391.1	
		Silage.....	1,938	.....	1,900	

Prices of feeds used:

Cottonseed meal.....	per ton..	\$41.00
Shelled corn.....	per bushel..	.80
Corn silage.....	per ton..	3.00

The calves of lot 1 consumed 299 pounds of cottonseed meal and 2,460 pounds of silage for each 100 pounds of gain in weight, while those of lot 2 consumed 195 pounds of cottonseed meal, 391 pounds of corn, and 1,900 pounds of silage to make the same amount of gain. Each 100 pounds of gain cost \$9.82 and \$12.44 for lots 1 and 2, respectively. The calves receiving cottonseed meal as the sole concentrate consumed 560 pounds more silage for each 100 pounds of gain in weight, but they consumed so much less concentrated ration that the gains cost almost 3 cents a pound less.

SLAUGHTER DATA.

The calves were driven from the farm at Abbott to West Point, Miss., and from there they were shipped to the St. Louis market. They were in transit 25 hours, and shrank 41 and 47 pounds per head for lots 1 and 2, respectively.

TABLE 27.—*Slaughter data (May 5, 1916, to January 5, 1917, 246 days).*

Lot No.	Number of calves.	Average final farm weight per head.	Average market weight per head.	Average shrinkage en route to market.	Shrinkage en route to market.	Average price paid per hundred-weight.	Average weight of carcass. ¹	Per cent dressed—	
								By farm weight.	By market weight.
1.....	25	Pounds. 685	Pounds. 644	Pounds. 41	Per cent. 5.9	\$8.05	Pounds. 340	Per cent. 49.6	Per cent. 52.8
2.....	24	735	692	47	6.4	8.47	379	51.5	54.7

¹ Farm weights less 2 per cent shrinkage.

The calves of lot 1 sold for \$8.05 per hundredweight, and those of lot 2 sold for \$8.47 per hundred pounds. The calves of lot 1 dressed out 52.8 per cent and those of lot 2 dressed out 54.7 per cent by market weights. The corn-fed calves were fatter than the cottonseed-meal calves at the end of the feeding test, and this was reflected in the dressing percentage.

FINANCIAL STATEMENT.

The financial outcome of this experiment was very satisfactory. The calves cost or were valued at \$5 per hundredweight in the spring. Cottonseed cake in the summer cost \$30.50 per ton, and the cottonseed meal in the winter cost \$41.50 per ton. Corn silage was charged at \$3 per ton, and pasture was charged in at 50 cents per calf per 28-day period.

Table 28 shows the financial outcome of the feeding of both lots of calves:

TABLE 28.—*Financial statement.*

Lot 1:

To purchase 25 calves—8,325 pounds, at \$5 per hundredweight---	\$416.25
To 15,575 pounds cottonseed cake, at \$30.50 per ton-----	237.52
To pasture, 179 days, at 50 cents per head per 28 days, 25 calves--	79.91
To 7,475 pounds cottonseed meal, at \$41 per ton-----	153.24
To 61,500 pounds corn silage, at \$3 per ton-----	92.25
To freight charges to market-----	43.75
To commission, \$15; yardage and feed, \$8.25-----	23.25
Total expenditures-----	1,046.17
By sale of 25 calves—16,100 pounds, at \$8.05-----	1,296.05
Total profit-----	249.88
Average profit per calf-----	10.00

Lot 2:

To purchase 24 calves—8,170 pounds, at \$5 per hundredweight---	\$408.50
To 8,856 pounds cottonseed cake, at \$30.50 per ton-----	135.05
To 17,568 pounds shelled corn, at 80 cents per bushel-----	250.97
To pasture, 24 calves, 179 days, at 50 cents each per 28 days-----	76.71
To 4,776 pounds cottonseed meal, at \$41 per ton-----	97.91
To 9,576 pounds shelled corn, at 80 cents per bushel-----	136.80
To 46,512 pounds silage, at \$3 per ton-----	69.77
To freight charges to market, 24 calves-----	42.00
To commission, \$14.40; yardage and feeds, \$7.92-----	22.32
Total expenditures-----	<u>1,240.03</u>
By sale of 24 calves—16,600 pounds, at \$8.48 per hundredweight--	1,407.63
By pork credit for hogs following calves-----	63.63
Total-----	<u>1,471.31</u>
Total profit on 24 calves-----	231.28
Average profit per calf-----	9.64

There were eight shoats which followed the calves of lot 2 while in the feeding lot from November 7, 1916, to January 5, 1917, or 60 days. These shoats got no feed other than what they picked up behind the calves. They cost $7\frac{1}{2}$ cents per pound in the fall when they were put in the feed lot. While they followed the calves they gained 470 pounds in weight, or almost 1 pound per head per day. The hogs sold for 10 cents a pound, making a total profit of \$63.63.

After the calves paid for all the feeds consumed at market prices, paid for the pasture at the rate of 50 cents per head per 28-day periods, and paid for themselves at the prevailing price in the spring and given a credit for pork produced they returned a profit of \$10 a head when fed as lot 1 and \$9.64 when fed as lot 2. If the shoats had cost 10 cents per pound and sold for 10 cents per pound they still would have returned a profit of \$47; and when the calves are given the credit for this amount of pork they produced, the profit per calf would have been \$8.91 per head instead of the actual profit of \$9.64 which was realized.

DISCUSSION OF RESULTS.

This experiment indicates that it is possible to handle the "short-aged" calves, which always occur to a certain extent in all herds, in such a manner as to realize a nice profit on them. As the calves are too young to give satisfactory and profitable results by giving a short feed in the fall and winter, it is a good plan to let them nurse the cows during the winter while maintaining the cows and calves in fair condition in an economical manner, weaning the calves when grass becomes good in the spring, and feeding them on grass during the summer. In case they did not become fat enough for the market while on grass or if the market was weak and unsatisfactory they could be finished in the feed lot for the Christmas market or for a later market if desirable.

Cottonseed meal proved a very satisfactory concentrated ration for the calves while on grass and also when being fed silage during the winter. There was a greater tendency for the cottonseed-meal-fed calves to grow instead of fattening than was the case with the calves fed on shelled corn supplemented with cottonseed meal. The cottonseed-meal-fed calves made satisfactory and economical gains when the kind and condition of pasture were considered, as the summer of 1916 was a most unfavorable one in the prairie of Mississippi for fattening cattle on grass.

The experiment indicates also that where corn can not be marketed readily it can be fed to calves very satisfactorily and at a good return. The corn-fed calves made better although more expensive gains than the calves fed on cottonseed meal alone. If the profits on the hogs and the increased selling price of the calves are taken into consideration, the corn-fed calves made almost as much profit as the others.

If all the feeds except corn are charged at market prices and the profit is considered, the value of the corn fed to the calves gave a return of \$1.57 per bushel for every bushel of corn consumed. It is seen, therefore, that the feeding of corn would have been exceedingly profitable to the man who could not have sold his corn in any other way and would have been much more profitable to market it in this way if a good market had been accessible.

Should the farmer who can sell his corn readily and purchase cottonseed meal for feeding sell his corn or feed it? To answer this question let us see at what price he would have to charge his corn to the calves in order to make as much profit as the cottonseed-meal-fed calves made. In this experiment, if the shelled corn had been charged at 77 cents per bushel, the calves of each lot would have made the same profit, namely, \$10 per head. If corn could not have been sold for enough over 77 cents per bushel for preparing it for market and marketing, it would have been much more profitable to feed it to calves than to sell it. This test indicates clearly that with good calves corn can be fed at a profit even though it is worth a high price. The better the calves, the more expensive corn can be fed without danger of loss. With scrub or cheap cattle the southern farmer can not afford to use high-priced corn.

In these experiments no charge has been made for labor, nor any credit given for the manure produced. The value of the manure will overbalance the cost of feeding, so that there is an indirect profit in calf-feeding which has not been included or discussed in the results.

This experiment indicates that while cattle are high-priced and good pastures can be obtained for grazing purposes, the problem of what to do with short-aged or late calves may be solved very profitably by handling in the same manner tried out in this test.

SUMMARY.

1. Short-aged calves that are too young to wean and put on feed in the fall can be fed grain while on pasture the following summer and sold directly off grass or finished in the dry lot.

2. During both the summer and the winter feeding periods the calves that were fed shelled corn and cottonseed meal made larger but more expensive gains than those fed on cottonseed meal as the sole concentrate.

3. Gains made during the summer are very much cheaper than those made in the dry lot during the winter.

4. The grain ration of the calves of lot 1 cost \$9.50 and that for lot 2, \$16.08 for the summer.

5. The calves cost \$5 per 100 pounds in the spring and the cost in the fall after all feed and pasture was charged against them was \$5.02 and \$5.73 per hundredweight for lots 1 and 2, respectively.

6. When on full feed, each calf of lot 1 ate $4\frac{1}{2}$ pounds of cottonseed cake per day; and of lot 2, 3 pounds cottonseed cake and 6 pounds of shelled corn.

7. The calves were fed 179 days on pasture and 67 days in the dry lot, or a total of 246 days.

8. The calves of lot 2, which received shelled corn, were much fatter than those of lot 1 when finished and they dressed out 2 per cent more. They also sold for 43 cents more per hundredweight.

9. Eight pigs following the calves of lot 2 made one pound per head per day gain and returned a pork credit per calf of \$2.65.

10. When the pork credit is considered the calves fed corn returned almost the same profit as the calves fed cottonseed meal.

11. For each calf of lot 2 to make the same profit as lot 1, namely, \$10 per head, the corn had to be charged at 77 cents per bushel instead of 80 cents.

VI. GENERAL DISCUSSION OF THE FIVE YEARS' EXPERIMENTS.

The prices of the feeds and cattle used varied so much from year to year that the financial statements of the various experiments are not strictly comparable. If cottonseed meal was very cheap one year and comparatively high another year, the financial outcome of the two experiments would be misleading. This is true of all similar experiments, and for this reason experimental data can not be used directly by a feeder where conditions are different from those reported in the experiment.

If the farmer is given certain data as to the average daily gains, the amount of feed required to make 100 pounds of gain, and if he

knows what his cattle and feed cost, he can figure out very closely how much profit he can make out of steer feeding if he receives $1\frac{1}{2}$, 2, $2\frac{1}{2}$, or 3 cents margin or spread on cattle. The data mentioned are given in each of the experiments reported in this bulletin, and can, therefore, be used by anyone familiar with figuring out profits on cattle feeding.

To put the work reported in this bulletin on a more comparable basis and to bring it more up to date some tabulations have been prepared which show the amount of feed required to make 100 pounds of gain, the cost of 100 pounds of gain, and the profit realized per calf in each experiment, if they had been sold at various margins. All calves are charged in at the average price of $6\frac{1}{2}$ cents per pound on the farm, and the average price of all of the feeds for the years 1915 and 1916 are used.

The Bureau of Crop Estimates furnished the following prices on various feeds. These are the average for good quality for the years of 1915 and 1916.

Cottonseed meal	per ton	\$36.00
Cottonseed cake	do	36.00
Shelled corn	per bushel	.86
Corn-and-cob meal	per ton	26.00
Cottonseed hulls	do	14.00
Mixed alfalfa hay	do	16.00
Corn silage	do	3.50
Corn stover	do	8.00
Cowpea hay	do	15.00
Oat straw	do	8.00

The prices of feed used in the calculation of Table 29 were as follows:

Cottonseed meal	per ton	36.00
Corn	per bushel	.86
Corn-and-cob meal	do	26.00
Corn chop	do	32.00
Cottonseed hulls	do	14.00
Corn silage	do	3.50
Alfalfa hay	do	18.00
Mixed alfalfa hay	do	16.00

Pasture 50 cents per head for 28-day period.

If these prices for the feeds are used the cost of 100 pounds of gain for the calves of lot 1 ranged from \$7.89 in 1911-12 to \$9.77 in 1912-13.

The cost of 100 pounds of gain for the corn-fed calves of lot 2 ranged from \$8.68 to \$9.65 per 100 pounds, or somewhat higher than for the cottonseed-meal-fed calves.

The calves of lot 3, which were fed a heavy corn ration, made still more expensive gains, the cost of each 100 pounds of gain ranging from \$7.77 to \$11.13.

TABLE 29.—Amount of feed consumed per hundred pounds gain and cost per hundred pounds gain.

Station and year.	Ration.	Lot 1.	Lot 2.	Lot 3.
Alabama, 1911-12.....	Feed per hundredweight gain:			
	Cottonseed meal.....pounds..	134	115	77
	Corn-and-cob meal.....do.....		58	154
	Cottonseed hulls.....do.....	528	566	602
	Mixed alfalfa hay.....do.....	222	238	255
	Cost per hundredweight gain.....	\$7.89	\$8.68	\$9.64
Alabama, 1912-13.....	Feed per hundredweight gain:			
	Cottonseed meal.....pounds..	175	144	176
	Corn chop.....do.....		72	
	Cottonseed hulls.....do.....	946	536	438
	Corn silage.....do.....		1,084	875
	Cost per hundredweight gain.....	\$9.77	\$9.39	\$7.77
Abbott, Miss., 1914-15..	Feed per hundredweight gain:			
	Cottonseed meal.....pounds..	214	172	112
	Corn-and-cob meal.....do.....		86	225
	Cottonseed hulls.....do.....	346	309	331
	Corn silage.....do.....	774	690	753
	Alfalfa hay.....do.....	207	191	217
Abbott, Miss., 1915-16..	Feed per hundredweight gain:			
	Cottonseed meal.....pounds..	213	88	
	Shelled corn.....do.....		353	489
	Corn silage.....do.....	1,318	1,025	769
	Alfalfa hay.....do.....	268	269	250
	Cost per hundredweight gain.....	\$8.55	\$9.65	\$11.13
Abbott, Miss., 1916-17: Summer.....	Feed per hundredweight gain:			
	Cottonseed cake.....pounds..	247	126	
	Shelled corn.....do.....		250	
	Pasture.....do.....			
Winter.....	Cost per hundredweight gain.....	\$5.04	\$6.58	
	Feed per hundredweight gain:			
	Cottonseed meal.....pounds..	299	195	
	Shelled corn.....do.....		391	
	Corn silage.....do.....	2,460	1,900	
	Cost per hundredweight gain.....	\$9.68	\$12.86	

The calf-feeding work of 1916-17 shows most clearly the value of pasture supplemented with a grain ration for fattening calves. The cottonseed-meal-fed calves of lot 1 made 100 pounds of gain in the summer for \$5.04, whereas in the winter the same gain in weight cost \$9.68. When one-third cottonseed meal and two-thirds shelled corn were fed as the grain ration the calves of lot 2 made gains during the summer at \$6.58 and during the winter at \$12.86 per 100 pounds.

In Table 30 no account is taken of the pork that would be produced behind the calves receiving corn, and this amount must be calculated and added to the profits for the corn-fed calves. There would be no pork credit for the calves of lot 1, fed cottonseed meal, and a smaller credit for those fed corn-and-cob meal than the ones fed shelled corn or broken ear corn. At the present prices of pork, it would be conservative to add a pork credit of \$2 to \$3.50 per calf for the calves of lots 2 and 3 for the last three years, depending upon the amount of corn fed to each lot. This amount of profit should be added to the profit shown in the table.

In Table 29 it is seen that in every year except 1912-13 where corn was fed the cost of the gains was more than where cottonseed meal was fed as the sole concentrate.

The profit per calf as shown in Table 30 is computed on the basis of a spread or margin of selling over purchase price of $1\frac{1}{2}$, 2, $2\frac{1}{4}$ and $2\frac{1}{2}$ cents per pound.

TABLE 30.—*Profit realized per calf if they sell for $1\frac{1}{2}$, 2, $2\frac{1}{4}$, and $2\frac{1}{2}$ cents above cost price of $6\frac{1}{2}$ cents per pound.*¹

Station and year.	Sold at margin of—	Profit per calf.		
		Lot 1.	Lot 2.	Lot 3.
	<i>Cents.</i>			
Alabama, 1911-12.....	$1\frac{1}{2}$	\$5.80	\$4.37	\$2.88
	2	8.75	7.17	5.48
	$2\frac{1}{4}$	10.24	8.58	6.97
	$2\frac{1}{2}$	11.65	9.98	8.33
Alabama, 1912-13.....	$1\frac{1}{2}$	2.99	4.52	5.50
	2	5.52	7.06	7.97
	$2\frac{1}{4}$	6.78	8.33	9.21
	$2\frac{1}{2}$	8.04	9.60	10.45
Abbeott, Miss., 1914-15.....	$1\frac{1}{2}$	-3.89	-5.99	-4.92
	2	-7.76	-2.11	-1.81
	$2\frac{1}{4}$	-7.79	-1.41	-.24
	$2\frac{1}{2}$	2.35	.11	1.29
Abbott, Miss., 1915-16.....	$1\frac{1}{2}$	3.98	-2.90	-7.81
	2	7.24	.42	-4.43
	$2\frac{1}{4}$	8.87	2.08	-2.73
	$2\frac{1}{2}$	10.50	3.74	-1.04
Abbott, Miss., 1916-17.....	$1\frac{1}{2}$	6.11	-4.12	.....
	2	9.33	-.66	.....
	$2\frac{1}{4}$	10.94	1.07	.....
	$2\frac{1}{2}$	12.55	2.79	.....

¹ No credit has been given in the table for the pork produced.

Table 30 shows that when the average price of feeds for the last two years is taken as a standard, the calves that were fed cottonseed meal as the sole concentrate would have made a nice profit every year, except one, on a margin of $1\frac{1}{2}$ cents per pound.

During the years 1911-12 and 1912-13, when ear corn ground into corn-and-cob meal was fed in very small quantities a bigger profit was shown on a margin of $1\frac{1}{2}$ cents than where corn was fed in larger amounts daily. The work of each of the first two years is strictly comparable with each other, and the work of each of the last three years is also comparable, but as light corn rations were fed the first two years and heavy ones the last three years, the two groups of years are not comparable with each other. In the work of the last three years, where a medium to heavy grain ration was fed, there would be naturally a larger pork credit per calf, otherwise the heavy corn feeding would have been very unprofitable.

The calves that were fed corn liberally made more rapid gains than calves fed on cottonseed meal alone and fattened much faster, as there was a tendency for the calves that were fed cottonseed meal as the sole concentrate to grow instead of fattening. The corn-fed

calves also sold somewhat higher because they were fatter; but though prime calves could not be made when cottonseed meal was fed as the sole concentrate, it was usually more economical and more profitable to feed cottonseed meal alone than to feed a combination of cottonseed meal and corn or a ration of corn alone. This is owing to the comparative cheapness of cottonseed meal with corn when the feeding value of the two concentrates is considered. As long as cottonseed meal remains cheap and corn relatively high in price the results probably will be the same. There are some exceptions to this, however. On farms where considerable corn is raised and can be marketed only at considerable expense, the farmer can get a good price for the corn by feeding it to his calves and hogs. The higher the quality of the calves the less danger of loss there is in feeding more expensive corn. Calves of high quality usually pay better returns for the feed consumed than scrub calves.

When corn was fed liberally the calves invariably finished out better than the cottonseed-meal-fed calves and usually made larger daily gains. They usually sold for somewhat more per hundredweight and killed out a higher percentage of dressed meat.

Although prime calves could not be made by feeding cottonseed meal as the sole concentrate, the calves became fat enough and made gains cheap enough to sell well and return a good profit year after year. While cottonseed meal continues relatively cheap, good profits can be made by feeding it to fattening calves.

Corn silage proved a much more satisfactory roughage for fattening calves than cottonseed hulls.

The calves made a profit every year when feeds were charged in at cost; but in some cases the profit was small, as the value of the manure has not been considered in writing up these tests.

GENERAL CONCLUSIONS FOR THE FIVE YEARS' CALF FEEDING.

The calf-feeding work reported in this bulletin covers a period of five years. The calves used in all of the experiments were very similar in age, size, breeding, and quality. Those fed during the first four years of the experimental work reported in this bulletin were fed in a very similar manner, as the general conditions under which the feeding was done were very similar. The calves averaged from six to eight months of age in the fall when they were put on feed.

In all five years' work there has been a comparison of the value of cottonseed meal and a combination of cottonseed meal and corn for fattening calves for the market. In some cases the corn was fed as corn-and-cob meal, in others as corn chop, and in still others as shelled corn, but the comparison of cottonseed meal and corn has remained throughout.

The roughage used during one year was not the same as that used another year, but each year the roughage was exactly the same for the lots which were being compared.

In the first two tests, where corn was substituted for cottonseed meal, the substitution was made pound for pound and the results were unsatisfactory, because a pound of corn has a much smaller feeding value than a pound of cottonseed meal; and the corn-fed calves therefore were getting a smaller amount of digestible nutrients and consequently did not do as well as the cottonseed-meal-fed calves. During the later experiments, where corn was substituted for cottonseed meal, the substitution was made in about the proportion of 2 pounds of corn for 1 pound of cottonseed meal.

The use of corn invariably increased the cost of the gains made, regardless of the kind and amount of roughage used. Where corn was fed very sparingly as a substitute for cottonseed meal, the amount or size of the daily gains of the calves was not increased; but where corn was fed liberally the calves made larger daily gains than the calves fed on cottonseed meal alone. The increased gains were not great enough, however, to overbalance or offset the increased cost of the gains, so the cottonseed-meal-fed calves were usually a little more profitable.

Unless the calves that were fed corn were followed by shoats to utilize the waste grain, the feeding of corn was not as profitable as the use of cottonseed meal as the sole concentrate.

In the South, during the last three years, there has often been a margin of 2 to 3 cents a pound between purchase price of calves at weaning time and selling price in the spring. Under such conditions, with the current prices of feedstuffs, the feeding of calves for the market has been very profitable.

The work of 1916-17 indicates that calves too young to wean and fatten for market in the fall can be made to pay a nice profit by letting them nurse the cows during the winter, feeding them grain on grass the following summer, and selling them in the fall, or by following the summer feeding with a short feeding in the dry lot and selling about Christmas or soon after.

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WM. A. TAYLOR, Chief



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PROFESSIONAL PAPER

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THE UTILIZATION OF WASTE TOMATO SEEDS AND SKINS.

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INTRODUCTION.

The manufacture of tomato products in the United States constitutes an industry of large and growing proportions and importance. Tomatoes serve as the basis for two general classes of products, in one of which the fresh whole tomatoes are used and in the other the pulp alone, as in the manufacture of catsups and soups. For this latter class large quantities of tomatoes are required, from which the seeds and skins at present are discarded as useless.

The increased interest in the production of foodstuffs throughout the country will doubtless result in an extension of all canning and packing operations, including tomato products. In the following pages attention is directed to the possible utilization of the waste tomato material, not only from the standpoint of food conservation, but as a profitable adjunct to the tomato-canning industry.

COMMERCIAL PRODUCTS FROM TOMATO REFUSE.

By proper treatment, tomato refuse may be made to produce two important products, namely, fixed oil and meal, both of which

possess considerable value. The seeds of the tomato contain a fatty oil of excellent quality, and the seed cake is valuable as a stock food.

Considerable work has already been done in foreign countries, especially in Italy, on the utilization of tomato waste. Battaglia (4)¹ in 1901 investigated tomato-seed oil and reported on its properties. Later, Kochs (9), in an investigation of certain residues, mentioned tomato-seed oil and discussed its properties, stating that 17.3 per cent of oil having an agreeable taste and smell could be obtained from the seeds.

In the manufacture of tomato products, Italy perhaps leads all countries. The industry there has assumed such proportions that the problem of the proper disposal of the residues has become an important consideration. Perciabosco and Semeraro (12) in 1910 investigated tomato residues with a view to extracting the fatty oil, determining also the industrial value of the oil and the fertilizer and feeding values of the residues after extraction. The oil extracted by carbon bisulphid was found to have properties similar to those of the oil previously reported by Battaglia. The fat-free residues were found to be useful for fertilizing purposes.

Harcourt (6) in 1907 called attention to the tomato refuse accumulating in increasing quantities at the canning factories in Canada. It was reported that a large portion of the refuse was flushed into near-by rivers, but in some cases it was allowed to accumulate near the factories, thus becoming a nuisance. Some of the refuse was spread over the land as a fertilizer. The manurial value was tested and found to compare favorably with barnyard manure in the three important elements, potash, phosphoric acid, and nitrogen.

Accomazzo (1) in 1910 stated that in the province of Parma, Italy, 850,000 quintals (83,660 tons) of tomatoes were used annually. This quantity would yield from 11,000 to 12,000 tons of skins and seeds, containing about 80 per cent moisture. After removing the greater portion of the moisture the residue would amount to about 3,000 to 4,000 tons, of which about two-thirds are seeds. It is stated that these seeds when extracted by pressure yield 18 per cent of oil and by solvents 20 per cent. It would therefore be possible to recover from 500 to 600 tons of oil from the waste seeds. Tomato-seed oil is stated to have a heat value about equal to that of olive oil. When treated with driers it acquires good drying properties and is also useful in soap making. The press cake is said to have excellent nutritive value.

Fachini (5) also recommends the extraction of oil from the seeds, but instead of drying the residue, as proposed by Accomazzo, he

¹ The serial numbers in parentheses refer to "Literature cited," pp. 14-15.

suggests a method of separating the seeds from the skins by agitating the material with water and allowing it to settle, whereupon the seeds fall to the bottom. The greater part of the water can then be removed from the wet seeds by centrifugal machines, after which the seeds are dried easily and the oil can be removed by extraction or pressure.

According to Consul Keena (8), Florence, Italy, the utilization of tomato waste and the extraction of the oil from the seeds was first attempted by a firm in Parma in 1910. The success of the undertaking led to the establishment of two other factories the following year. About 5,000 metric tons (1 metric ton=2,204 pounds) of wet tomato waste, corresponding to 1,500 metric tons of dry waste, were worked out for the extraction of the oil and manufacture of the meal. These operations yielded 150 tons of oil, 800 tons of oil cake, and 500 tons of tomato skins.

Tomato-seed oil has been utilized in the manufacture of soap, and the conversion of the crude oil into an edible oil is also receiving attention. The press cake is used in the manufacture of stock feed, while the skins are suggested as a fertilizer.

The seeds are sold at Parma for 14 cents per 100 pounds, while at Naples the wet residue is sold at 4 to 8 cents per 100 pounds. This residue, which ferments readily, must be collected and dried daily. When dry it sells at \$1.75 to \$2.20 per 100 pounds.

More recently attention has been called by Shriver (14) to the vast quantities of tomato seeds and skins accumulating as waste products from the rapidly growing canned-tomato industry in Italy. The problem of the proper disposition of this waste has been receiving attention since 1908, at which time a manufacturing plant was established in Milan, with branch drying plants at Parma, Ceriale, Cervia, Piacenza, and Pilastro.

The oil is sold in the crude state for \$7 per 100 pounds, and the refined oil for \$8.75 per 100 pounds. The press cake is mixed with the skins and other ingredients and sold as stock feed.

The yield of oil from the seeds is stated by Shriver to be about 20 per cent by pressure and 22 per cent by solvents. In 1913, from 100 to 150 metric tons of oil and 1,000 metric tons of stock feed were manufactured in Milan from the press cake and skins.

Bailey and Burnett (3), working with American tomato seeds, extracted the oil by pressure and found that it could be refined and bleached easily and was apparently a satisfactory food oil.

ACCUMULATION AND DISPOSAL OF TOMATO WASTE.

PERCENTAGES OF SEEDS AND SKINS.

For the preparation of tomato pulp, the fresh tomatoes, after being carefully sorted to remove the culls, are thoroughly washed by a

stream of water under pressure, then passed into receptacles where they are cooked with steam, and afterward are transferred to a cyclone machine, which removes the pulp. The seeds and skins pass out and are discarded. By the cold process the washed tomatoes pass directly to the cyclone machine.

The total quantity of tomato waste which accumulates annually in the United States depends not only upon the pack of any particular season but also upon the percentage of seeds contained in the fresh tomatoes. The seed content varies with the variety of tomato. Estimated from the figures given by Accomazzo (1), Italian-grown tomatoes contain 14.7 per cent of wet waste, of which about 80 per cent is water. After removing the greater portion of the water, the waste amounts to 4.8 per cent. Of this waste, which probably still contains some moisture, 73 per cent is seeds. The dry waste as it occurs in Italy is stated to contain about 66 per cent by weight of seeds (15). These percentages are considerably higher than the results obtained from American-grown tomatoes.

Two experiments in different localities were made with American-grown tomatoes which had been used for pulping purposes, to determine the percentage of seeds and skins. The quantity of fresh tomatoes used in the two experiments was 2,320 pounds and 5,344 pounds, respectively. The results were as follows: Wet waste, 5.43 and 5.44 per cent; dry waste, 1.11 and 0.95 per cent. The dry waste in these experiments contained 46.3 and 42.8 per cent seeds and 53.7 and 57.2 per cent skins, respectively.

According to Street (16, p. 128-129), fresh tomatoes contain 1.35 per cent dry waste, consisting of 49.3 per cent seeds and 50.7 per cent skins. Using these figures as a basis for calculation, American-grown tomatoes contain on the average about 1.13 per cent dry waste, of which 46.1 per cent is seeds and 53.9 per cent skins. Fresh tomatoes therefore contain the equivalent of 0.52 per cent dry seeds and 0.61 per cent dry skins.

In order to learn the approximate annual output of tomato refuse in the United States, the writer personally visited 21 of the largest tomato-pulping firms. These manufacturing concerns operate largely in Indiana, Iowa, Michigan, and Ohio in the Middle West, and New Jersey, Pennsylvania, New York, Delaware, and Maryland in the East. Detailed figures regarding the output of refuse were not available in each State. The extent of the industry, however, may be realized when it is learned that in Indiana alone 120,000 tons of tomatoes are pulped annually. Applying the percentages previously mentioned, the amount of dry waste in this one State would be about 1,356 tons, or 624 tons of seeds and 732 tons of skins.

Not all the firms engaged in pulping tomatoes could be reached; therefore accurate information in regard to the total quantity used

annually could not be obtained. But from the figures given by the firms visited, supplemented by correspondence with other firms, it is estimated that 275,000 tons are pulped annually. Adding to this the tonnage of culls, from which also the seeds and skins could be separated, a conservative estimate would be about 300,000 tons.

This tonnage, of course, would vary from year to year. However, owing to the increasing demand for tomato products, the tonnage will tend to increase each year.

The quantity of wet waste resulting annually would be about 16,000 tons, which would yield approximately 3,000 tons of dry waste. This dry waste would yield about 1,500 tons of dry seeds and 1,800 tons of dry skins.

DRYING THE WASTE MATERIAL AND SEPARATING THE SEEDS.

An important problem in connection with the utilization of tomato waste is the drying of the mass and separating the seeds from the skins. According to Shriver (14, p. 21-22), this problem is handled in Italy in the following manner:

The wet seeds and skins are passed through a press to remove as much of the moisture as possible. They are then passed through a desiccator, or drier, in which the material is kept in constant motion by means of horizontal conveyers, finally emerging from the machine in a dry condition. Heat is applied to the drier by means of steam pipes or by forced air.

It is stated that about 10 tons of residue can be dried in 24 hours. The final operation consists in passing the dried material through a machine supplied with a series of sieves and fans, which results in the complete separation of the seeds from the skins.

A number of types of desiccators, or driers, are manufactured in the United States which would be admirably suited for drying the wet waste. It has been suggested that a sugar-beet drier would handle the material efficiently. No great difficulty should be experienced in constructing a separator consisting of sieves and fans for the separation of the seeds from the skins.

EXTRACTION OF TOMATO-SEED OIL.

Two methods of extraction are applicable for obtaining fatty oil from seeds. The pressure method is perhaps the simplest and most expeditious, being well adapted to seeds containing a fairly high percentage of oil. The most careful manipulation of this process, however, leaves a residual portion of the oil in the press cake. The expeller type of press is perhaps the best adapted for seeds having a comparatively low percentage of oil. Even with this type of machine a small percentage of oil remains in the press cake. This, however, is not a total loss, since the value of the cake is enhanced by the presence of some fat. A distinct advantage of the pressure

method is in the better quality of the product obtained. Pressed oils usually contain less impurities and consequently are more readily and effectively refined.

When the maximum percentage of oil is desired from certain materials the volatile-solvent method of extraction serves best. The principal solvents which may be employed are benzine, petroleum ether, gasoline, and carbon tetrachlorid. A disadvantage of this method is in the inflammability of many of the solvents, necessitating careful handling and operation. This trouble is largely overcome by the use of carbon tetrachlorid, which is noninflammable and possesses a higher boiling point than any of the other solvents and hence is capable of effecting more complete recovery. Oils obtained by the solvent extraction method are usually less pure than expressed oils, containing much coloring matter and other impurities extracted by the particular solvent employed. No great difficulty is experienced, however, in refining the oils thus obtained. Pressed oils also require refining.

Apparatus of the continuous-extraction type is usually employed. This kind of apparatus minimizes the quantity of solvent used and prevents loss of the solvent during the operation. Practically all the solvent may be recovered from the oil and residue and thus be available for further use. A practical example of the use of a volatile solvent for the extraction of fatty oil is the use of benzine in the extraction of soy-bean oil (11). The disadvantages of the solvent method as compared with the advantages of the pressure method are largely offset by the lower cost of the apparatus, the smaller expense of operation, and the higher yield of oil obtainable.

Continuous extractors and hydraulic presses are obtainable from American manufacturers of chemical and pharmaceutical machinery.

Either of the two methods mentioned may be used effectively in the extraction of oil from tomato seeds. The solvent extraction method was used for obtaining the samples in the experiments described in this bulletin. The apparatus employed was the continuous-extraction type, the solvents used being ether and carbon tetrachlorid. The yield of oil from the ground seeds with either solvent was practically the same, averaging 22 per cent. The crude oil was pale greenish yellow in color with a fatty, slightly rancid odor and fatty, slightly bitter taste.

In refining the crude oil the objectionable odor was removed by passing steam through the oil until little or no odor was perceptible. The deodorized oil was then heated on a steam bath for about one hour with fuller's earth (kaolin) and finally filtered while hot through filter paper. This procedure effected decolorization of the oil to a marked degree. The refined oil possessed a very pale yellowish color with bland fatty and agreeable nutlike taste and smell.

PHYSICAL AND CHEMICAL PROPERTIES OF THE CRUDE AND THE REFINED OILS.

Some of the more common physical and chemical constants of the crude and the refined oils were determined, as shown in Table I. For purposes of comparison the properties of some of the tomato-seed oils of foreign origin are also included in the table.

TABLE I.—Physical and chemical constants^a of tomato-seed oil from domestic and foreign tomatoes.

Physical and chemical constants.	Domestic oil.		Foreign investigators.			
	Crude.	Refined.	Accomazzo (1).	Battaglia (4).	Kochs (9).	Percia-bosco and Semeraro (12).
Color.....	Pale greenish yellow.	Very pale yellow..	.....	.....	Brownish red.	.....
Odor.....	Fatty, nutlike, slightly rancid.	Fatty, bland, nutlike.	.....	.....	Agreeable, tomatolike.	.....
Taste.....	Fatty, slightly bitter.	Fatty, bland, nutlike; no bitter aftertaste.	.....	.....	do.....	.....
Specific gravity.	0.9216 ^b	0.9184 ^b	0.920 ^c	0.922 ^c	0.920 ^c	0.9244. ^c
Index of refraction.	1.4694 ^d	1.4715 ^d.....	.....	1.4730.....	.....	.....
Congeaing point	Turbid at 0° C.; yellow gelatinous mass at -7° C.	Turbid at 2° C.; solid, very pale yellow mass at -10° C.	.....	.....	Thick liquid at -9° C.	.....
Acid value.....	8.8.....	2.5.....	.....	26.3.....	9.....	1.823.
Saponification value.	190.4.....	188.6.....	183.6.....	190.4.....	183.6.....	189.4.
Iodin value.....	108.....	114.2.....	117.....	106.9.....	117.8.....	87.7.

^a Determined according to standard methods (17).^b At 24° C.^c At 15° C.^d At 25° C.

From Table I may be noted the general effect of the refining process upon the physical and chemical properties of the oil. The color, odor, and taste of the refined oil show much improvement over the same properties of the crude oil. The specific gravity and index of refraction show changes due to the removal of impurities by the refining process. The congealing point of the refined oil has likewise changed. The acid value is materially lower than that of the crude oil, owing to the removal of the free fatty acids. The saponification and iodine values show similar differences due to the removal of impurities.

Among the oils of foreign origin the properties reported by Battaglia correspond more nearly to those of the crude oil of domestic origin, while the remainder compare favorably in most cases with the refined domestic oil.

CHEMICAL EXAMINATION OF THE OIL.

In addition to the chemical constants a further examination of the refined oil was made to determine its approximate composition. The determinations were made according to standard methods (17, p. 138-139). No soluble acids were found, but 96.2 per cent of insoluble

acids were present. These insoluble acids were separated into the solid and liquid acids by means of the lead-ether method (17, p. 45). The mixed acids were found to consist of solid acids 17.54 per cent and liquid acids 75.84 per cent.

The physical and chemical properties of the insoluble acids and the solid and liquid acids, were determined with the results shown in Table II.

TABLE II.—*Physical and chemical properties of insoluble, solid, and liquid acids of tomato-seed oil.*

Physical and chemical properties.	Insoluble acids.	Solid acids.	Liquid acids.
Color.....	Pale golden yellow; partly solid.	Snowy white, flaky....	Pale golden yellow.
Odor.....	Fatty, nutlike.....	Fatty.....	Pleasant, nutlike.
Taste.....	Sweetish, fatty.....	Fatty, tallowlike.....	Sweetish, nutlike, becoming slightly bitter.
Specific gravity at 25° C.	0.9100.....	.....	0.9013.
Index of refraction at 25° C.	1.4655.....	.....	1.4654.
Congeeing point.....	+21.5° C. to +20.5° C....	Melting point; 33.5° C....	.....
Neutralization value.....	180.....	204.....	192.3
Iodin value.....	101.3.....	.....	130.

The solid acids, comprising 17.54 per cent of the oil, probably consist largely of palmitic and stearic acids with neutralization values of 219.1 and 197.5, respectively. The neutralization value 204 would indicate a mixture of these two acids. Although the melting point of crude solid acids is considerably lower than either palmitic or stearic acids, which melt when pure at 62° C. and 69° C., respectively, it is very probable that this is due to the presence of impurities.

Calculating from the neutralization value 204, the mean molecular weight of the solid acids was found to be 275. This indicates the presence of palmitic and stearic acids, since the molecular weight of these acids are 256 and 284, respectively.

In order to ascertain the approximate proportions of these two acids in the mixed solid acids, a calculation was made according to the method suggested by Lewkowitsch (10, v. 1, p. 515), using as a basis 275, the mean molecular weight of these solid acids. By this method, the percentage of palmitic acid was found to be 67.8 and of stearic acid 32.2.

Since 17.54 per cent of the original oil consists of solid acids, the oil therefore contains palmitic acid 11.88 per cent and stearic acid 5.64 per cent. Because the palmitic and stearic acids exist in the oil as palmitin and stearin, it is necessary to reduce the above figures to terms of these glycerids. The glycerid palmitin contains 95.29 per cent of palmitic acid, and the glycerid stearin contains 95.73 per cent of stearic acid. By calculation, therefore, it is found that

tomato-seed oil contains 12.47 per cent of palmitin and 5.89 per cent of stearin.

The liquid acids, constituting 75.84 per cent of the oil, possess properties which indicate the presence of oleic acid and possibly some linoleic acid.

The specific gravity of the liquid acids, 0.9013 at 25° C., would indicate a mixture of oleic and linoleic acids, since the specific gravity of pure oleic acid is 0.893 at 25° C. and linoleic acid 0.9206 at 14° C. The index of refraction corresponds closely with oleic acid, which possesses an index of refraction of 1.4603 at 25° C.

The neutralization value of 192.3 is somewhat lower than that of pure oleic acid, 198.9, and pure linoleic acid, 200.4. The iodine value, 130, possibly also indicates a mixture of oleic and linoleic acids with a preponderance of oleic acid. Some commercial oleic acids have iodine values as high as 100 to 110, while pure linoleic acid possesses an iodine value of 181.42.

Using the method of Lewkowitsch (10, v. 1, p. 457), for calculating the approximate proportions of oleic and linoleic acids present from the iodine value as a basis, it was found that the liquid acids consist of 56.8 per cent of oleic acid and 43.2 per cent of linoleic acid. Reducing these percentages of oleic and linoleic acids to terms of the original oil, which consists of 75.84 per cent of liquid acids, it is found that the oil contains approximately 43.07 per cent of oleic acid and 32.76 per cent of linoleic acid. These acids are contained in the oil in the form of the glycerids olein and linolein, which contain 95.7 and 95.67 per cent, respectively, of oleic and linoleic acids. By calculation it is found, therefore, that the oil consists approximately of 45 per cent of olein and 34.2 per cent of linolein.

A summary of the results of the chemical examination of tomato-seed oil indicates the following approximate composition: Olein, 45 per cent; linolein, 34.2 per cent; palmitin, 12.47 per cent; stearin, 5.89 per cent—the remaining portion consisting of free acids and unsaponifiable matter.

AVAILABLE QUANTITY OF THE OIL.

Estimating the annual output of dry tomato waste from the various pulping plants in the United States at 3,390 tons, there would result from this waste 1,560 tons of dry seeds. The quantity of oil capable of being extracted from these seeds is readily ascertained. Since by extracting with volatile solvents 22 per cent of the oil can be obtained, the total available quantity would be about 343 tons annually. This quantity would, however, increase each year with the increased output of tomato products.

USES AND VALUE OF THE OIL.

Classifying fatty oils as drying, semidrying, and nondrying, tomato-seed oil possibly falls into the semidrying class, bordering, however, very nearly on the nondrying class. In order that the nature of tomato-seed oil may be better understood, a comparison is given in Table III of some of the more important properties of a number of oils of commerce belonging in the same class with tomato-seed oil (10, v. 2).

TABLE III.—*Physical and chemical properties of tomato-seed oil and several important oils of commerce.*

Oils.	Specific gravity at 15° C.	Congeeing point (°C).	Saponification value.	Iodin value.	Index of refraction at 20° C.
Tomato seed.....	0.9184 <i>a</i>	Turbid at -2; pale yellow solid mass at -10.	188.6	114.2	<i>b</i> 1.4715
Cotton seed, Lewko- witsch (10, p. 149-150).	0.922 to 0.930 ...	3 to 4.....	191 to 196.5	100.9 to 116.9	1.4722
Soy bean, Lewkowitsch (10, p. 123).	0.924 to 0.927 ...	+15 to + 8....	190.6 to 192.9	121 to 124	.....
Sesame, Lewkowitsch (10, p. 173).	0.9203 to 0.9260...	- 4 to - 6....	187.6 to 194.6	103 to 115	1.4728
Corn, Lewkowitsch (10, p. 131-132).	0.9213.....	-10 to -20...	188 to 193.4	112 to 130.8	<i>c</i> 1.4768

a At 24° C.

b At 25° C.

c At 15.5° C.

The similarity of tomato-seed oil to the commercial oils given in Table III indicates the classification of this oil. The oils mentioned in connection with tomato-seed oil are applied commercially in a number of ways. As edible oils they are highly prized. On account of their drying properties some are employed extensively in the manufacture of paints and varnishes, while others find important application as soap stock.

Tomato-seed oil, with properties similar to cottonseed, soy-bean, sesame, and corn oils, should be equally useful and applicable to the same purposes as these oils of commerce.

Experiments conducted with tomato-seed oil by Dr. A. D. Holmes, of the Office of Home Economics, U. S. Department of Agriculture, to determine its digestibility, showed that the oil possesses a coefficient of digestibility of 97, comparing favorably with olive, almond, cottonseed, peanut, coconut, sesame, walnut, and brazil-nut oils. Well-refined tomato-seed oil is therefore to be recommended for culinary purposes. As a salad oil it should prove very satisfactory. The edible quality of the oil suggests also its possible hydrogenation and application as a margarine oil.

An experiment to determine its saponifying properties was conducted in order to obtain information regarding its possible use as soap stock. By cold saponification with caustic soda and subse-

quent salting and pressing, a soap of good texture with excellent lathering qualities was produced. If combined with oils rich in palmitin or stearin, satisfactory toilet soap doubtless could be prepared. Owing to the present threatened shortage of oils for the manufacture of soaps and glycerine the utilization of tomato-seed oil as a soap stock asserts itself.

Experiments to determine the drying properties of the oil showed that 16 days were required to form a soft, sticky film. The nature of the film as well as the time of drying could in all probability be improved and hastened by the addition of siccatives or driers to the oil. It appears, therefore, that the oil possesses a certain value as a paint or varnish oil.

The value of the oil in commerce would necessarily depend upon the particular use to which it could be applied and to the demand in general for fatty oils. From the results of the investigation, it appears that it should prove a valuable addition to the edible or condimental oils now in use. Likewise it should find an important place among the much-needed soap oils of commerce.

TOMATO-SEED MEAL.

UTILIZATION FOR STOCK FEEDING.

The residue remaining after extracting the oil from the seeds constitutes the meal. The utilization of this meal as stock feed is suggested. In order to ascertain the approximate composition of the meal, a careful analysis was made. The results are shown in Table IV, together with analyses of some commercial stock feeds as given by Henry and Morrison (7, p. 634-636).

TABLE IV.—*Composition of tomato-seed meal as compared with various commercial stock feeds.*

Feeding stuff.	Constituents (per cent).					
	Moisture.	Ash.	Protein.	Nitrogen-free extract.	Fiber.	Ether extract.
Tomato-seed meal.....	7.15	4.64	37.0	29.10	22.11	.....
Cottonseed meal.....	7.8	6.6	39.8	27.4	10.1	8.3
Sunflower seed (prime).....	10.0	4.2	34.8	21.8	10.9	18.3
Sesame-oil cake.....	9.8	10.7	37.5	21.7	6.3	14.0
Palm-nut cake.....	10.4	4.3	16.8	35.0	24.0	9.5
Rape seedcake.....	10.0	7.9	31.2	30.0	11.3	9.6
Linseed meal (new process).....	9.6	5.6	36.9	36.3	8.7	2.9

In moisture and ash content, the tomato-seed meal compares favorably with the other feed stuffs. In protein content, it ranks with sunflower seedcake, cottonseed meal, sesame-oil cake, rape seedcake, and linseed meal, being considerably higher than palm-nut cake and some-

what lower than cottonseed meal. Since the tomato-seed meal which was subjected to analysis was from ether-extracted seeds, the ether extract does not enter into consideration. The meal from seed expressed by hydraulic pressure would contain from 5 to 7 per cent ether extract, which represents the residual fat left in the cake. The crude-fiber content is relatively high as compared with the other feeds, being lower, however, than that of palm-nut cake. The content of nitrogen-free extract, consisting largely of carbohydrates, is higher than in such meals as cottonseed, sunflower, and sesame, and lower than in palm-nut, rape-seed, and linseed cake.

From the results of the analysis and the comparison with standard stock feeds it would appear that tomato-seed meal possesses properties of considerable value for stock feeding. In this connection it may be stated that in Italy, where the utilization of tomato residues is in practical operation, experiments with the meal or cake have demonstrated its value as a feed for stock. Aguet (2) has reported a factory in operation at San Giovanni a Teduccio, near Naples, for the industrial manufacture of tomato seedcake. Feeding trials conducted at the Royal Higher School of Agriculture at Portici with milch cows showed tomato seedcake to be equal in food value to linseed cake. Later, Scarpitti (13) conducted extensive investigations with the seedcake as a feed for milch cows, stating that it is richer than flaxseed cake in protein and fat and is superior to it in its influence upon the weight and lacteal secretion of the cows.

Shriver (14, p. 21-23) describes the manufacture of stock feed from the dried tomato waste after the extraction of the oil. A number of grades of stock feed under the name "Nutritivo" are manufactured by a firm at Milan, Italy, from the dried skins mixed with molasses and the meal from the extracted seeds. This feed for cattle is sold at prices ranging, according to quality, from \$1.32 to \$1.49 per 100 pounds. The seedcake after the oil is expressed is sold at \$1.32 per 100 pounds.

AVAILABLE QUANTITY OF THE MEAL.

After extracting the oil from the estimated quantity of tomato seeds which accumulate annually, there would remain as a by-product about 1,200 tons of the meal. In addition to this large quantity of meal there would also be available about 1,800 tons of tomato skins. In view of the use to which the dried skins are applied in Italy by incorporating them with the meal, this would increase the total available quantity to about 3,000 tons.

SUMMARY.

The foregoing investigation shows that the vast quantities of tomato refuse accumulating each year at tomato-pulping factories can

be reduced to two products, namely, fixed oil and meal, each of which may be made commercially useful.

The oil from the seeds should find ready disposal as an edible oil or as a soap oil, as shown by the experiments made to determine its applicability to these purposes. By proper treatment it can be made useful as a drying oil for paint and varnish purposes.

The meal has been shown by analysis and comparison with other meals to possess valuable qualities as stock feed, and the utility of the meal for this purpose should therefore be assured.

The accumulation of tomato residues occurs principally in two sections of the United States, namely, the North-Central States lying east of the Mississippi and north of the Ohio Rivers and the North Atlantic States. The reduction of this waste material to oil and meal could be handled most logically by establishing reducing plants at some central point in each of these sections, where the crude material could be collected with the least expense for transportation and handling. A cooperative plan of manufacture would perhaps be the most feasible and effective method for establishing the industry upon a practical basis.

In view therefore of the threatened shortage of fatty oils and in the interest of food conservation, tomato refuse may be considered as an available source for the manufacture of oil and oil cake. As the demand for tomato products increases, the quantity of this waste material will also increase, and it is suggested as an economic measure of both agricultural and industrial importance that the utilization of this material be considered.

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W. J. SPILLMAN, Chief

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FACTORS OF SUCCESSFUL FARMING NEAR MONETT, MO.

By W. J. SPILLMAN, *Chief, Office of Farm Management.*

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THE AREA IN WHICH THE SURVEY WAS MADE.

During the summer of 1915 an analysis was made of the business of 274 farms lying within a radius of about 5 miles of the town of Monett, in southwestern Missouri,¹ the center of the survey area lying in the line between Barry and Lawrence Counties. This locality is typical of a considerable area lying along the western margin of the Ozark area and the eastern margin of the western prairies. In general, the highest uplands were originally prairie and the slopes and bottom lands timbered.

The surface would be described, for the most part, as gently rolling. A small stream flows from east to west through the town of Monett. The bottom lands bordering it form a tract from a quarter to a half mile wide, flanked on each side by a moderate rise of land hardly prominent enough to be described as bluffs. Beyond is gently rolling upland originally covered, for the most part, with blackjack timber (a species of oak) and extending back to the prairie areas covering the ridges between streams.

¹ The farm analyses on which this bulletin is based were made by Messrs. Walter J. Tubbs, Ivan Allen, C. E. Allred, and F. D. Crum, under the direction of Mr. F. H. Branch. Mr. R. D. Jennings has rendered material assistance in tabulating the data and computing the tables. Acknowledgment is also due to the many farmers who kindly furnished details concerning their farm business, thus making this study possible.

The soil of this region was formed mostly from limestone in which was imbedded a considerable amount of flint, sometimes in rather large masses. The limestone itself was dissolved out by rain water carrying small quantities of carbonic-acid gas in solution, leaving the impurities of the limestone (consisting mainly of small or large particles of flint) to constitute the resulting soil. On the slopes, where the finer particles of soil have been washed away, the land is rocky, the rocks consisting of angular fragments of flint, for the most part from 1 to 3 or 4 inches in diameter. Elsewhere, especially where the land was originally covered with blackjack timber, the soil is rather gravelly. The alluvial soil of the bottoms contains more or less gravel. On the higher ridges, which were originally prairie, the soil is somewhat finer in texture and less inclined to be gravelly. These prairie soils were formed in part from shales. On the whole, the soil may be described as gravelly loam or gravelly silt loam. Like most medium to heavy soils, it is fairly fertile, especially when abundantly supplied with decaying organic matter such as manure and the refuse from crops.

The first settlers who came into this region came mainly from wooded regions and took up land along the streams. Most of the stream bottoms have been in cultivation for about three-quarters of a century. About 40 or 45 years ago farmers began to come into the region from prairie districts, especially from Illinois. These settled on the prairies. The prairie lands have thus been in cultivation somewhat less than half a century.

The wooded slopes between the prairies and the bottom lands have been cleared and put into cultivation mainly during the last 30 years, the amount of woodland left being scarcely sufficient to supply local farm needs.

THE LOCAL AGRICULTURE.

Wheat is decidedly the most important of the local crops at the present time, corn being second in importance. The percentage of the crop area devoted to wheat for the crop year 1913-14 on the farms included in this survey was 48.8, or practically half of the entire area. Corn occupied 25.1 per cent. The position of these two crops, so far as acreage is concerned, has been practically reversed in the last 20 years. In 1890, according to the census for that year, corn occupied 46 per cent of the crop area in Barry County and 41 per cent in Lawrence County. In the same year wheat occupied 24 per cent of the crop area of Barry County and 33 per cent in Lawrence County.

The reason for this change in the status of wheat and corn in this locality is not known definitely. The present high price of wheat is not responsible for it, for the crop to which this survey relates was

sown in the fall of 1913, when the price of wheat was still moderate. It is probable that the frequent occurrence of hog cholera in this region may be partly responsible for the decrease in the acreage of corn and the increase in the acreage of wheat, as the number of hogs kept on these farms has decreased considerably in recent years.

The oat crop occupied 10.8 per cent of the crop area on these farms, which is about a normal acreage for this crop. A great many farmers here do not grow oats. In general, the crop is not satisfactory, it being too far north for winter oats and too far south for spring oats. Not infrequently the crop is an entire failure. The reason for the persistence of the oat crop under such unfavorable conditions is its value as feed for horses and the scarcity of other kinds of roughage. For the most part, the oats are cut and bound and fed in the sheaf. A portion of the crop may be thrashed and fed as grain.

Various hay crops occupy about 9 per cent of the crop area of the farms surveyed, which is approximately the status occupied by such crops for the last quarter of a century. About two-thirds of the hay land is in timothy or timothy and clover, the rest being in millet, sorghum, oats, rye, etc.

FRUITS.

The town of Monett is the center of one of the most important strawberry-producing regions in this country. The acreage of berries is not large when compared with that of wheat and corn, or even hay, but it is very considerable when the intensity of the strawberry enterprise is taken into consideration. Of the 244 farms¹ included in this bulletin, 1.5 per cent of the total crop area was in strawberries, two-thirds of which were in bearing. Other fruit crops also are more or less prominent. Apples occupy 2.6 per cent of the total crop area, and other fruits six-tenths of 1 per cent. While small areas of fruit are found on farms of all sizes, it is mainly the smaller farms that make fruit growing a specialty.

YIELDS PER ACRE.

The average yield of corn on these farms for the year 1914 was 25 bushels per acre, which is approximately normal. The yield of this crop in Barry County at the last three censuses was, respectively, 26, 25, and 17 bushels. In Lawrence County it was 26, 21, and 24 bushels.

The average yield of oats for the year of this survey was 24 bushels, as compared with census figures of 21, 22, and 23 for Barry County, and 22, 25, and 26 for Lawrence County. This again is a normal yield.

¹ Thirty farms operated by owners who rented out a part of their land are omitted in most of the discussion which follows.

The yield of wheat for the year of the survey was somewhat above the normal, being 16 bushels as compared with Barry County yields of 13, 10, and 12 bushels at the last three censuses and Lawrence County yields of 14, 12, and 14 bushels. This higher yield of wheat is believed to be due to a recent marked increase in the use of commercial fertilizers rather than to climatic conditions for the year.

The yield of hay was about half a ton per acre. This is a little less than half the normal yield according to the census figures. But the minor place occupied by hay crops in the agriculture of this locality renders this low yield of hay relatively unimportant.

The average yield of strawberries the year of the farm survey was 74 crates per acre, as compared with Barry County yields of 62 and 50 crates for the last two census years, and Lawrence County yields of 90 and 56 crates. Considering the marked variability in the yields of this crop, the yield for the year of the survey may be considered as practically normal.

FARMS CLASSIFIED ACCORDING TO TYPE OF FARMING.

The 244 farms included in this study may be divided into five groups according to type of farming carried on, though in most cases the line of division between the various types is more or less arbitrary. One hundred and sixteen of them may be classed as grain and live-stock farms. They consist of farms on which the principal income is from grain, in nearly all cases wheat, with more than 10 per cent of the total income from some one type of live stock, usually cattle or hogs.

On 66 of the farms grain (wheat in most cases, corn in a few others) constituted the only source of income exceeding 10 per cent of the total receipts. These are classed as grain farms. Forty-one are classed as grain and fruit farms. They include farms on which both grain and fruit are important sources of income, with no other income from any one source exceeding 10 per cent of the total.

Seventeen of the farms are classed as fruit farms. The average income from fruit on these farms is about 60 per cent of the total. About half of these fruit farms had 10 per cent or more of their income from cattle.

There were four farms which made the dairy business an important feature. On two of them dairying was the only important source of income; on the other two grain was about as important as dairying, but these four farms were grouped together because they were the only ones on which the dairy business was a principal feature of the farming. Because of the small number of dairy farms they are omitted from most of the tabulations for the reason that averages of only four items have little meaning.

SOURCES OF RECEIPTS.

Table 1 shows the sources from which these 244 farms obtained their income.

TABLE 1.—*Sources of receipts (244 farms near Monett, Mo.).*

[Figures represent percentage of total receipts.]

Source.	Grain and live stock farms (116).	Grain farms (66).	Grain and fruit farms (41).	Fruit farms (17).	Source.	Grain and live stock farms (116).	Grain farms (66).	Grain and fruit farms (41).	Fruit farms (17).
	<i>Per ct.</i>	<i>Per ct.</i>	<i>Per ct.</i>	<i>Per ct.</i>		<i>Per ct.</i>	<i>Per ct.</i>	<i>Per ct.</i>	<i>Per ct.</i>
Corn.....	4.3	8.0	1.6	2.2	Horses.....	6.5	5.2	3.7	3.5
Oats.....	.8	1.0	.6	.3	Sheep.....	.1			
Wheat.....	48.2	60.7	34.9	1.7	Hogs.....	7.1	2.0	3.6	2.7
Small fruits.....	2.3	1.8	30.1	50.3	Poultry.....	5.0	4.9	4.5	4.2
Other fruits.....	1.3	.3	7.7	8.5	Other stock.....	.4	.2	.2	.1
Other crops.....	1.1	1.6	2.2	2.6	All stock.....	31.5	19.0	17.2	25.4
All crops.....	58.0	73.4	77.1	65.6	Miscellaneous.....	7.5	7.6	5.7	7.3
Cattle.....	15.4	6.7	5.4	11.9					

It will be seen that there is a considerable degree of diversity in the farming of this region. Wheat is decidedly the most important source of income on the grain and live-stock and on the grain farms, about equal to small fruits on the grain and fruit farms, while on the fruit farms there is no other important source of income from crops than small fruits, especially strawberries. Among the various classes of live stock, cattle lead as a source of income in all the groups. Poultry furnishes from 4 per cent to 5 per cent of income in each group. Hogs are unimportant, except on the grain and live-stock farms, where the income from them constitutes about 7 per cent of the total receipts.

PERCENTAGE AREA IN DIFFERENT CROPS.

Table 2 shows for the four principal types of farming the percentage of land devoted to various crops.

TABLE 2.—*Relation of type of farming to percentage area in different crops (244 farms near Monett, Mo.).*

[Figures represent percentage of land devoted to crops specified.]

Crop.	Grain and live stock farms.	Grain farms.	Grain and fruit farms.	Fruit farms.	Crop.	Grain and live stock farms.	Grain farms.	Grain and fruit farms.	Fruit farms.
	<i>Per ct.</i>	<i>Per ct.</i>	<i>Per ct.</i>	<i>Per ct.</i>		<i>Per ct.</i>	<i>Per ct.</i>	<i>Per ct.</i>	<i>Per ct.</i>
Corn.....	26.9	26.0	19.6	33.9	Other forage.....	1.3	1.1	0.4	5.8
Wheat.....	48.5	53.1	50.2	9.0	Strawberries.....	.5	.4	5.1	9.3
Oats.....	11.3	11.3	8.8	7.4	Other small fruits...	.1		1.2	10.8
Hay.....	6.8	5.1	5.0	7.7	Apples.....	2.1	1.0	6.3	5.8
Millet.....	1.0	.4	.6	2.6	Other fruits.....	.3	.5	1.0	3.2
Sorghum.....	.7	.3	.6	2.9	Other crops.....	.5	.4	1.2	1.6

On the grain and live-stock farms and on the grain farms corn occupies about one-fourth of the total crop area, wheat about half, oats about 11 per cent, hay 5 to 7 per cent, with no other crop occupying as much as 2 per cent of the area except in the case of apples on the grain and live-stock farms. On the grain and fruit farms the area of corn is smaller, and that of wheat is about the same as in the two preceding groups, while strawberries rise to 5 per cent and apples to 6 per cent of the entire crop area. On the fruit farms corn occupies one-third of the total crop area, wheat oats, and hay are about equally important, occupying from 7 per cent to 9 per cent, strawberries occupy 9.3 per cent, and other small fruits 10.8 per cent, while apples are nearly as important as in the preceding group.

KINDS OF FRUIT AND THEIR LOCAL IMPORTANCE.

Of the 17 farms here classed as fruit farms, strawberries were produced on all but one, and on this one there was an acre of new planting of strawberries. On three of these farms the area of bearing strawberries was 1 acre; on four it was $1\frac{1}{2}$ acres; on one it was 2 acres; on four $2\frac{1}{2}$ acres; on one 3 acres; on one 4 acres; and on two 6 acres. The total sales of strawberries on 16 of these farms amounted to \$8,251, an average of \$516 per farm.

The next most important fruit is blackberries. They were grown on 12 of the 17 fruit farms. One of the farms with 6 acres of strawberries had also 12 acres of blackberries. The other farm having 6 acres of strawberries had 10 acres of blackberries. Two farms had a quarter of an acre of blackberries each, 5 farms had from 1 to $1\frac{1}{2}$ acres, and the remaining 3 from $3\frac{1}{2}$ to 5 acres. The 2 farms having large acreages of both strawberries and blackberries also had large acreages of raspberries, one 10 acres and the other 7. Three other farms had from 1 to $2\frac{1}{2}$ acres of raspberries. There were 5 acres of dewberries on one farm and a quarter of an acre of grapes on each of 2 farms.

Of the tree fruits, nearly all fruit farms had apples; but only five derived any income from this source, the largest amount being \$250. Seven farms also had small acreages of peaches, in only two cases more than $1\frac{1}{2}$ acres, the area in these two cases being respectively $4\frac{1}{2}$ and 6 acres. The sales of peaches on the two farms last mentioned were respectively \$300 and 600; on the other three farms \$15 to \$75 per farm. Two farms had small incomes from cherries, one from plums, and one from pears, in no case exceeding \$100. One farm had three-quarters of an acre in nursery stock, from which sales amounting to \$170 were made. The total acreage of blackberries on these farms was 41 acres and the total acreage of strawberries 43; but more than half the blackberries were on two farms, so that strawberries may be considered by far the most general fruit crop of the region.

RELATION OF TYPE OF FARMING TO SIZE OF FARM.

In Table 3 the 244 farms are divided into groups based on area in crops. The table shows for each of these size-groups the percentage of farms that follow the different types of farming.

TABLE 3.—Percentage of farms in each of six size-groups, devoted to type of farming specified (data from 244 farms in the vicinity of Monett, Mo.).

Type.	Number.	Acres in crops.					
		39 or less.	40-79	80-119	120-159	160-199	200 or more.
		<i>Per cent.</i>	<i>Per cent.</i>	<i>Per cent.</i>	<i>Per cent.</i>	<i>Per cent.</i>	<i>Per cent.</i>
Grain and live stock.....	116	19	43	59	66	60	67
Grain.....	66	19	34	24	23	20	33
Grain and fruit.....	41	24	20	12	8	20	.....
Fruit.....	17	38	2	2	.....	.....	.....
Dairy.....	4	.....	1	3	3	.....	.....
Number.....	244	37	103	58	35	5	6

It will be noticed that of the farms having less than 40 acres in crops 38 per cent are fruit farms and 24 per cent grain and fruit farms. In this group there are also 19 per cent of grain and live stock farms and 19 per cent of grain farms. These figures bring out the important fact that among the small farms fruit is a predominating enterprise. This is as it should be, for these farms are too small to give full employment in the production of corn and wheat, the staple crops of the region, and it is necessary, in order that their owners shall make an adequate living, that they introduce enterprises that give more work per acre than corn and wheat.

In the next size-group, consisting of farms having from 40 to 79 acres of crops, the largest percentage consists of grain and live-stock farms, with grain farms next, followed by grain and fruit farms. Only 2 per cent of these farms are fruit farms, while one of them is a dairy farm.

In the third size-group, containing farms with 80 to 119 acres of crops, more than half of them are grain and live-stock farms. This is true of each of the three remaining groups. In these last four groups there is still a considerable percentage of grain farms and a few grain and fruit farms. There is a single fruit farm in the third size-group. Two of the dairy farms are in this group, and one in the next higher group.

The last line of the table shows the number of farms in each size-group, while the first column shows the number of farms in each type-group.

INVESTMENT.

Table 4 shows the relation between size of farm and the total investment and the relation between type of farming and total investment. One of the fruit farms is omitted from this table and from

Table 5 for reasons that will be given later, but this makes only a slight change in the figures.

TABLE 4.—Average total investment on farms of different size and type (243 farms near Monett, Mo.).

Type.	Acres in crops.					Average.
	65 or less.	66-95	96-125	126 and over.	All sizes.	
Grain and live stock.....	\$5,926	\$9,335	\$12,875	\$17,386	\$11,015	Acres. 95
Grain.....	5,084	7,824	¹ 12,251	.....	7,395	76
Grain and fruit.....	5,190	² 10,114	.....	.....	7,594	68
Fruit ³.....	.....	.....	.....	.....	4,919	36
All types.....	.....	.....	.....	.....	9,033	81

¹ 96 and over.

² 66 and over.

³ Not including one exceptional farm

PROFITABLENESS OF THE VARIOUS TYPES.

Table 5 shows the relation between labor income and size of farm, and the relation between labor income and type of farming. It may be explained here that labor income is what the farmer gets for his labor and managing ability. It is found by deducting from the net income of the farm a fair rate of interest on the investment, which in this case was taken to be 5 per cent. In addition to labor income as obtained in this manner the farmer has what the farm furnishes toward the family living.

TABLE 5.—Labor incomes on farms of different size and type (243 farms near Monett, Mo.).

Type.	Acres in crops.				
	65 or less.	65-95	96-125	125 and over.	All sizes.
Grain and live stock farms.....	\$117	\$321	\$617	\$759	\$438
Grain farms.....	41	313	414	.....	192
Grain and fruit farms.....	232	598	.....	.....	410
Fruit farms ¹.....	.....	.....	.....	.....	294
All types.....	.....	.....	.....	.....	370

¹ Not including one exceptional farm.

As previously stated, one of the fruit farms is omitted from this tabulation. It was a very exceptional farm. It had 6 acres of strawberries, from which the sales amounted to \$1,468; 10 acres of blackberries, with sales of \$1,650; 10 acres of raspberries, with sales of \$900; 5 acres of dewberries, with sales of \$175; 10 acres of apples, with sales of \$180; and 6 acres of peaches, with sales of \$600. There was also 1 acre of young cherry trees. This farm is thus seen to be a highly specialized fruit farm. That its owner was an expert fruit

grower is attested by the fact that his labor income amounted to about \$2,500. That is, the net income of his farm was \$2,500 more than 5 per cent on his investment.

The relation between labor income and the size of farm as indicated by the area in crops is brought out very strikingly in Table 5. Taking first the grain and live stock farms, those in the group having 65 acres or less in crops each made only \$117 more than interest on their investment. As the area in crops increases the labor income increases, averaging \$759 for the group having 125 or more acres in crops. The grain farms and the grain and fruit farms tell the same story.

In all the surveys that have been made by the Office of Farm Management the results have shown conclusively that men of average ability must farm rather large areas in order to secure a satisfactory income. It is only the exceptional man that can realize the ideal of the "little farm well tilled." The average man should not try to do so. Just how large a farm should be for best results it is difficult to say. A good deal depends upon the type of farming. A farm of an intensive type—that is, one which requires a great deal of labor and working capital for each acre in cultivation—may be smaller than one devoted to enterprises requiring less labor and working capital.

The two-man farm has many advantages as opposed to a one-man farm, for in a great many farm operations two men are needed. So far as profit of the owner is concerned, there appears to be no upper limit to the size of farms except the managerial ability of the operator; but when farms are larger than fair-sized two-man farms—that is, farms that will give two men constant employment throughout the year—certain important disadvantages to the community appear. In the first place, the community is filled up with a class of hired labor which is not an addition to the permanent citizenship; farm houses are farther apart; there are fewer children for the district school; and it is more difficult to secure good roads. The two-man farm may, for many reasons, be considered as approaching the ideal for American conditions.

There is room in every community for a few farms devoted to the production of vegetables and fruits, and these may well be small farms because of the intensive labor such farming involves. This is especially true when the markets for the products of such farms are local. But when the farmer must depend upon distant markets and is thus thrown into competition with other regions engaged in similar types of farming, the small, intensive farm is placed at a serious disadvantage. Only about 4 per cent of the total crop area of the entire country is devoted to fruits and vegetables, yet this area supplies approximately the entire demand for products of this class. A relatively slight increase in the production of fruits and vegetables re-

sults in flooding the market and thus lowering prices below the point of profit. Farming based wholly on vegetables and fruits to be sold in distant markets is thus decidedly a speculative business. In general it is an unsafe kind of farming, though in some years it may be highly profitable.

THE PROPER STATUS OF THE STRAWBERRY INDUSTRY IN SOUTH-WEST MISSOURI.

A farm that is large enough to give full employment to the labor available to the owner in the production of wheat, corn, and live-stock products can be made profitable in this region without depending on fruit as a source of income. Yet even on these farms a small acreage of strawberries properly tended is a desirable enterprise. In some years the income from them will be small, but in other years it will be considerable. Even if the crop is an entire failure, the farmer is not crippled financially.

On farms that are too small to give full employment in the production of wheat, corn, and live-stock products there is greater need of some intensive crop like strawberries as a means of giving employment to farm labor; that is, of increasing the magnitude of the farm business. The force of this remark is shown by the experience of farmers in this community, for by far the greater portion of the strawberry area is on the smaller farms, as should be the case. However, Table 5, showing the average labor income from different types of farming, shows that the very small farms devoted mainly to fruit are not as satisfactory as larger farms on which grain and live stock are the main sources of income.

In this connection it may be noted that the average value of man labor per crop-acre on the grain and live-stock farms was \$5.16, on the grain and fruit farms \$7.45, while on the 17 fruit farms it was \$14.92, or nearly three times as much as on the grain and live-stock farms.

The number of acres of crops per man on the four types of farms was as follows: Grain and live stock, 59.3; grain, 54.3; grain and fruit, 42.5; fruit, 22.3. This shows the greater intensity of fruit farming as compared with the other types prevailing in the region.

THE SPECULATIVE NATURE OF FRUIT ENTERPRISES.

Fruit crops of all kinds are occasionally a complete loss from untimely frost. This has been the case with the strawberry crop in the vicinity of Monett, Mo., once in the last 10 years.

In occasional years also prices are so low that no profit is made in the business. These are years when the crop is unusually good in

a number of the leading fruit-producing sections of the country. This region has experienced two such years in the last decade.

These occasional years which produce no profit and sometimes result in rather heavy loss make fruit growing a speculative business. In the long run the good crops or the high prices, or the occasional combination of a good crop with high prices, will bring in enough money to make the business profitable in localities that are well adapted to it, as this region undoubtedly is to the strawberry crop. But the uncertainty of a profit in any particular year renders it unwise for the farmer to depend entirely on income from such enterprises. On farms devoted largely to fruit growing this uncertainty may be obviated partially by having several kinds of fruit, for it is hardly likely that all of them will fail to produce a profit in any one year. The most successful fruit farm found in this survey was really a diversified fruit farm. It must be remembered, however, that it takes a man of very unusual ability to make a success with a business of this character. Where fruit is a minor enterprise, such diversification is not so necessary and may even be quite undesirable.

If there is a good local market which renders shipping to distant points unnecessary, there is considerable advantage in growing several kinds of fruit; but where shipping is necessary the saving from shipping in car lots is so great as to place the producer of small lots at a disadvantage. Diversification in fruit growing as a means of insurance against crop loss must therefore be undertaken only after careful consideration of the marketing problem.

Another factor which must be taken into consideration is the danger from disease and insect pests to which fruit crops of all kinds are exposed. Occasionally a disease gets a start among strawberries, appears in the nurseries, and is spread over a large region before its presence is suspected. This causes heavy loss, not only to the nurseryman, but to those who have bought plants from him.

With all these disadvantages, however, the facts indicate that the strawberry business is a good one for the farmers of this region. It seems to be clear also that in the vast majority of cases the proper place of this crop is represented by a few acres. The smaller the farm the larger the acreage of strawberries required to fill in the labor schedule. The fact that the largest acreage of strawberries on any one farm was 6 acres is significant. This is about what an ordinary farm family can take care of except at harvest time. On the larger farms 1 or 2 acres of strawberries would generally be desirable.

Nothing has been said here about the amount of labor required in harvesting the strawberry crop, since no particular local difficulty appears to arise in this connection. The work is made more or less a festival, and thousands of people from the surrounding towns come

into camp near the fields for the few weeks when there is a rush of work of this kind. The amount of labor required for harvesting the crop is therefore not really a limiting factor in the acreage that the farmer can grow. The limit is represented rather by the area which he and his family can tend at times other than harvest.

MAINTENANCE OF SOIL FERTILITY.

The systems of farming which prevail generally in this region are not such as to maintain satisfactorily the fertility of the soil. As a result the yields on most farms are low. The three more important factors in maintaining crop yields are the use of manure, the plowing under of sod crops or green manure crops, and the use of commercial fertilizers. On most of these farms the amount of live stock kept is small compared with that kept on farms farther north. The amount of manure produced on the farm is not sufficient to maintain the fertility of the soil at a satisfactory level. Furthermore, on account of the general mildness of the climate, farm animals are not kept indoors much of the time, and a good part of the manure thus is not available for distribution on the tilled fields. Farmers therefore get relatively little from the manure actually produced on the farm.

In order to determine the results actually obtained from manure the farms in this survey were divided into two equal groups, the first consisting of those farms having less live stock than the average per hundred acres of crops, and the second of those having more than the average. A comparison was then made between these two groups of farms with respect to the average yield of each of the more important crops. The difference in favor of the farms having the more live stock was as follows: Corn, $1\frac{1}{2}$ bushels per acre; wheat, 0.6 bushel; oats, 2.5 bushels; hay, 0.1 ton.

When the relative acreage of these crops and the average price of their products for the last 10 years are taken into account this difference in yield in favor of the farms having more live stock than the average amounts to \$5.14 per year for each animal found on the farms having most live stock over and above those found on farms having least live stock. In other words, under the average conditions which prevail in this locality the farmer, on the average, actually gets in crop returns \$5.14 from the manure of each 1,000-pound animal or its equivalent in smaller animals. This is a very low valuation for manure, a fact which undoubtedly is due largely to the small proportion of the manure that is actually applied to the fields. By taking the best possible care of manure, by distributing this manure in the fall of the year on land that is to be devoted to corn the next year, and either disking it into the land or plowing

shallow before cold weather it is probable that these farmers would get practically double the result they now get from this manure.

In this connection it may be stated that in Chester County, Pa., where the live stock consists mainly of dairy cows which are kept in stables practically all winter and at nights during most of the summer and where the manure is managed with unusual care the value of manure per cow was found by the method above outlined to amount to between \$15 and \$16 a year.

Table 6 shows the average yield of corn and wheat on the two groups of farms designated as grain and live-stock farms and grain farms. This table shows that on the average the grain and live-stock farms obtained 3.7 bushels more corn per acre than did the straight grain farms. On the other hand, the grain farms obtained an average of 0.6 of a bushel more wheat per acre than the grain and live-stock farms. This difference is due to two causes. In the first place, manure is applied mainly to corn land on both groups of farms. The grain and live-stock farms, having more manure, get larger yields of corn. But wheat gets comparatively little benefit from the manure, dependence being placed on commercial fertilizers for this crop. Table 6 shows that the grain farmers used more fertilizer than the grain and live-stock farmers. Hence they get larger yields of wheat. The figures of this table show that, for those farms using commercial fertilizers, the grain farmers used \$11 worth more per 100 acres of crops than did the grain and live-stock farmers.

TABLE 6.—Yield of corn and wheat on grain and live stock and on grain farms (182 farms near Monett, Mo.).

Type.	Corn.	Wheat.	Fertilizer bought per 100 acres of crops.	
			Farms reporting.	All farms.
Grain and live stock farms.....	Bu. 26.8	Bu. 16.1	\$44.5	\$33.0
Grain farms.....	23.1	16.7	55.5	40.3

Studies of methods of maintaining good yields have shown that the plowing under of sod crops is very important. Crops of this character are not much grown in this region, almost the only sod crop being a few acres of timothy, and usually this is left down for many years and pastured rather closely, so that even when it is plowed up not much effect results from the sod plowed under. In the absence of sod crops and of abundant manure the plowing under of crops especially sown for the purpose becomes important. But

this is a practice very little followed in this region. This phase of the problem of maintaining soil fertility will be referred to again in discussing the organization of farms in this area.

To show how important from the standpoint of profit good crop yields are, the data given in Table 7 will be of interest. In order to make the meaning of this table clear, it is necessary to tell what the crop index is. To say that the crop index of a particular farm is 90 means that the average yield of crops on this farm is 90 per cent of the average of the community. The farms included in this survey were divided into three groups, the first consisting of those on which the crop index was 90 or less, the second those having a crop index from 90 to 110, and the third those with a crop index of more than 110. There were 88 farms in the first group, 86 in the second, and 70 in the third. The average size of farm was nearly the same in each group. The average of the crop indexes of the first group was 76, the second 100, and the third 129. The average labor income of the first group was \$122, of the second \$377, and of the third \$676. These figures show the outstanding importance of keeping the land fertile. It is one of the most important problems confronting farmers in this region.

TABLE 7.—*The effect of crop index on profits (244 farms near Monett, Mo.).*

Item.	Groups based on crop index.		
	90 and under.	90.1 to 110.	110.1 and over.
Number of farms.....	88	86	70
Average crop index.....	76	100	129
Average labor income.....	\$122	\$377	\$676

ORGANIZATION OF SOME TYPICAL FARMS.

The organization of three typical grain and live-stock farms is shown in Table 8. Each of these farms has from 105½ to 107 acres in crops. It happens also in each case that the operator owns part of the land and rents additional land. The first one rents 62 acres, the second one 40, and the third one 38. These farmers have recognized the fact that it is easier to make a satisfactory income on a large farm than on a small one, and have chosen a very satisfactory means of enlarging their business in the absence of sufficient capital to own all the land they can till. It will be noted that they have almost exactly the same amount of live stock, the investment in this item being about \$1,100 in each case. On one of them the value of the buildings, other than the dwelling, is very low. This is due to the fact that the buildings are very old and practically ready to be torn down.

TABLE 8.—Three successful grain and live-stock farms (designated I, II, and III) operated by owners renting additional land (Monett, Mo., area).

THE FARM.

Item.	I.	II.	III.
Area in crops.....acres..	105½	106	107
Area in pasture.....do..	34	15	37
Area rented.....do..	62	40	38
Investment of operator.....dollars..	9,493	7,568	10,493
Value of real estate per acre.....do..	56	48	61
Value of live stock.....do..	1,127	1,132	1,094
Value of implements and machinery.....do..	215	305	168
Feed and supplies on hand.....do..	111	101	191
Cash for current expenses.....do..	40	30	40
Value of dwelling.....do..	750	800	500
Value of other buildings.....do..	75	400	500

CROPS.

Kind.	Acres.			Yield per acre. ¹			Sales.		
	I.	II.	III.	I.	II.	III.	I.	II.	III.
Corn.....	41	27	49	35	33	37	\$340	\$55	\$589
Wheat.....	59	64	58	16	14	22	700	623	874
Oats.....	5	10	.....	15	27	.....	.....	.....	.....
Strawberries, new.....	.....	4	.....	.....	.....	.....	.....	.....	.....
Blackberries.....	½	.....	.....	36	.....	.....	22	.....	.....
Grapes.....	.....	¼	.....	.....	.....	.....	.....	.....	.....
Total crop sales.....	.....	.....	.....	.....	.....	.....	1,062	678	1,463

¹ Yields given are: For corn, wheat, and oats, bushels; for berries, crates; for grapes, baskets.

LIVE STOCK.

Kind.	Number.			Sales and increases in value.		
	I.	II.	III.	I.	II.	III.
Cows.....	5	4	5	\$230	\$260	\$350
Young cattle.....	3½	2	6	85	70	10
Steers.....	1	.....	.....	8	.....	.....
Total income from cattle.....	.....	.....	.....	323	330	360
Including dairy products, amounting to.....	.....	.....	.....	230	260	225
Horses and mules.....	4	5	8	25	103	—20
Colts.....	.....	2	3	.....	100	120
Hogs.....	11	12	13	95	175	112
Poultry.....	65	65	100	66	59	96
Miscellaneous.....	.....	.....	.....	94	64	204

RECEIPTS, EXPENDITURES, AND PROFITS.

Item.	I.	II.	III.
Total receipts.....	\$2,070	\$1,835	\$2,604
Rent.....	406	322	294
Other expenses.....	380	582	433
Net income.....	1,285	931	1,877
Interest on investment at 5 per cent.....	475	378	525
Labor income.....	810	553	1,332

TABLE 8.—*Three successful grain and live-stock farms (designated I, II, and III) operated by owners renting additional land (Monett, Mo., area).—Con.*

FACTORS AFFECTING PROFITS.

Item.	I.	II.	III.
Income per cow from sale of dairy products.....	\$46	\$65	\$45
Feed bought.....	75	105	.....
Fertilizers bought.....	10	.....	20
Value of family labor.....	30	6	54
Cost of labor hired.....	45	182	93
Months of labor on the farm.....	14.5	18.6	17.2
Average crop yields in percentage of community average.....	111	103	140

The second section of the table shows the crops grown on these farms—first, the acreage of each crop; second, the yield per acre; and third, the sales of crop products. Each farm has approximately 60 acres of wheat. The second farm has only 27 acres of corn, but the other two have between 40 and 50 acres. It will be seen later that the second farm is not as successful as the other two. Too much land is in wheat. This is shown by the yield of crops on these farms. On the second farm the yield of wheat is only 14 bushels, while on the third it is 22 bushels. Two of the farms have small acreages of oats, none of which is sold. The second farm has undertaken to increase its income by adding 4 acres of strawberries, which is probably wise in this case, though the acreage is a little large for the conditions. The first farm has a small patch of blackberries, from which there was an income of \$22. The second farm has a small patch of grapes, but with no income from this source.

A study of the results given later in this table leads to the conclusion that the second farm is not so well organized and managed as the first and third. It has too much of its land in wheat, too little in corn, and too much in oats. The presence of grapes on the farm, a crop not well adapted to the region, confirms this conclusion. It will be noticed that the total income from the sale of crops on the second farm is only two-thirds to one-half as much as on the other two.

The next section of the table shows the live stock on these farms. Each farm has from four to five cows and from two to six head of young cattle. One of the farms reports a steer, which was a calf raised on the farm. The total income from cattle on each farm was from \$323 to \$360, of which \$225 to \$260 was from the sale of cream. These farmers were patrons of a creamery. The second farm raised two colts, and the third raised three. The third farm has too many horses for its size, but this defect is balanced by the raising of colts. The income from hogs varies from \$95 to \$175, and from poultry from \$59 to \$96. Both of these sources of income could be made more important with profit.

The total receipts on these farms, shown in the next section of the table, vary from about \$1,800 on the second to \$2,600 on the third.

The amount of rent they pay runs from about \$300 to \$400. Other expenses run from about \$400 to \$600. The high expenses on the second farm are due to the large amount of labor hired, which comes to \$182. On the other two farms this figure is less than \$100.

The net income, after deducting rent and other expenses, varies on these three farms from \$931 to \$1,857. This represents interest on the investment and wages for the labor and managing ability of the operator. Deducting interest on the investment, these three farms have labor incomes of from \$500 to \$1,300. These are considerably above the average for the region. Especially in the case of the first and third farms the labor incomes are very satisfactory.

The last section of the table shows a few of the factors which affect the general results obtained on these farms. The most important figures are those relating to the average yield of crops on these farms, given in the last line of the table. On the first farm the average yield of crops is 11 per cent above the average for the farms surveyed in the community, on the second 3 per cent above, while on the third farm it is 40 per cent above. It will be noticed that the labor income is approximately proportional to these figures expressing the average yield of crops on these farms.

Two of the farms obtained incomes from the sale of cream amounting to about \$45 per cow. The other sold \$65 worth of cream per cow. The amount of feed bought is small, the third farm, with its good yields, spending nothing for this purpose.

The total amount of labor on these three farms was equivalent to from 14.5 to 18.6 months of labor for one man. In other words, these farms are intermediate between one-man and two-man farms. Undoubtedly it would be profitable to convert each of them into full two-man farms by the addition of a little more live stock, a small acreage of forage crops, and a small acreage of strawberries.

The organization of the grain farms in this region differs from that of the grain and live stock farms mainly in the smaller amount of live stock kept, the greater acreage of land devoted to wheat, and the smaller acreage devoted to corn. On the grain and fruit farms the organization differs from that of the grain and live-stock farms by the introduction of a few acres of fruit, usually of strawberries, and by the smaller amount of live stock kept.

ORGANIZATION OF DAIRY FARMS.

As previously stated, four farms were found in this survey having considerable income from dairy products. The smallest number of cows on any of these four farms was 13 and the largest number 28. The income from the sale of dairy products on the four farms

was, respectively, \$1,840 from 28 cows, \$1,125 from 17 cows, \$600 from 20 cows, and \$624 from 13 cows. The farm having 28 cows raised 12 acres of corn and 10 acres of sorghum fodder; also 4 acres of millet and 3 acres of rye for hay. It had only 52.5 acres of crops, there being only 14 acres of wheat. The other three farms had from 100 to 135 acres of crops, including from 40 to 60 acres of wheat. One of these farms had 30 acres of corn, 15 of which was cut for silage. Because of the large number of cows on these farms it was necessary to supplement the corn by other kinds of forage. As already stated, one of the farms did this by growing 10 acres of sorghum fodder, 4 acres of millet, and 3 acres of rye hay. Another, which had 20 acres of corn, grew also 20 acres of sorghum fodder. The farm which had 15 acres of corn for grain and 15 acres of silage had 12 acres of clover for hay and 15 acres of rye pasture. The other farm had 40 acres of corn, 5 acres of cowpeas, and 25 acres of oats.

Two of these farms sold all their milk at retail in the town of Monett, the retail price being $4\frac{1}{2}$ cents a quart. The income per cow for milk sold on these two farms was, in both cases, \$67. A third farm obtained \$200 for retail milk at 5 cents a quart and \$400 from cream sold to the creamery at an average of 25 cents per pound for butter fat. The fourth farm sold only butter, the average price being $27\frac{1}{2}$ cents, and the income from this source being \$624. The labor incomes on these farms were \$1,691, \$552, \$663, and \$1,299, respectively.

A good dairy cow should produce 4,000 or 5,000 pounds of good milk a year. The average pounds of milk per cow on these four farms, not counting the milk consumed on the farm, was as follows: 3,188, 3,743, 2,030, and 2,268. On three of them the cows were all Jerseys, some of them pure bred and others grades. One of the farms had Jersey grade cows with a Hereford bull. It also had four pure-bred Hereford cows and was probably changing from the dairy business to the beef-cattle business. It would be a great mistake for a dairyman to use a bull of a beef breed if he wishes to continue in the dairy business.

Judging by the experience of the majority of farmers here the proper status of dairying in this region, except for the few farms that are needed to supply milk to the town, is represented by the keeping of a few cows mainly as a means of converting roughage and other unsalable materials into a salable product, the cream being sold to creameries and the young stock being raised mainly on waste products of the farm. These cows should be either good dairy cows or good animals of a beef breed, the principal income from them in the latter case being from the sale of young stock.

A WELL-ORGANIZED TWO-MAN FARM.

These studies indicate that a satisfactory business can be conducted on a well-organized farm in this region. The most important difficulty confronting the farmers here appears to lie in the fact that the system of farming which seems to be best adapted to local economic conditions does not provide satisfactory means of keeping up the fertility of the soil. The most important factors in maintaining fertility are sod crops, manure, and fertilizers. The area of sod crops grown on these farms or needed in the local farm economy is very small and has very little influence on the fertility of the soil. Particularly is this the case when the sod, which usually is timothy, is kept for several years and pastured rather closely before being plowed up.

The amount of live stock kept on these farms is not only small, but such animals as are maintained are kept out of doors a very large part of the time and a great deal of the manure is lost, so far as the field crops are concerned.

Aside from the loss of manure from unconfined live stock, the principal wastage on these farms is in corn fodder and wheat straw. There is every reason to believe that if cowpeas were planted with all the corn at the time the corn is planted, using two cowpea seed for every grain or corn, and then cutting the corn for fodder, it would pay these farmers to keep enough live stock to consume these corn stalks with the cowpea vines on them. If the stock kept for this purpose are dairy cows it will be necessary, of course, to buy considerable quantities of mill products to feed with the roughage. Whether this will pay will depend on the dairy quality of the cows kept. Conditions are not highly favorable to the dairy industry here. They are rather favorable to the raising of beef cattle. A considerable herd of cows of a beef breed could be maintained on these farms largely on roughage in winter and pasture in summer, and as this roughage is now available it would seem that this business ought to add considerably to the farm income in this region. Particularly would this be true if the cows were such as to produce \$45 to \$60 worth of dairy products per year in addition to a good calf.

In this connection it may be mentioned that in recent years quite a number of farmers in this general region have stocked their farms with pure-bred beef cattle, and the results are proving to be very satisfactory. This is a type of cattle farming that does not require a great deal of labor and that provides an outlet for the wastes which now occur on these farms. At the same time it does not require the purchase of large quantities of mill stuffs, for these animals can be maintained very well on cornstalks and cowpea fodder of good quality, a little straw, and a little corn, with perhaps an

occasional feed of bran or shorts. If good pastures are provided for the summer season, the expense of keeping a mature herd of this kind will be rather small.

These studies indicate that a well-organized two-man farm in this region might be based upon the following crops: Corn and cowpeas, 40 acres; wheat, 60 acres; miscellaneous forage crops, such as soy beans, sorghum, oats, alfalfa, each in small acreages, say 2 to 4 acres; half an acre of garden; $1\frac{1}{2}$ acres of apple orchard, mainly for home use. There might also be 3 acres of strawberries, 2 in bearing. This would give 117 acres of crops.

Two men, with four good horses, and with all the heavy work done with four-horse implements, could tend all these crops easily and do all the work, except at harvest time, without additional help; and they would have time to spare.

A good complement of live stock for such a farm would be two mules and four high-grade brood mares, these four mares doing the full work of two horses, and when bred to a sound pure-bred stallion or the same type or breed should raise two colts each year. These two colts, when sold at a year old, should bring at least \$100. Since the two mares not at work could be maintained rather cheaply and could help to consume some of the wastage on the farm, it is believed that this \$100 income from colts would more than justify the keeping of the two additional mares.

Five cows, either of a dairy breed or of a beef breed, with five young cattle constantly on hand, would, with the help of the horses, consume the larger part of the waste of the farm, together with the small areas of miscellaneous forage crops mentioned above.

Two good brood sows, each raising two litters a year, amounting to at least 20 pigs during the year, would be about the right complement of swine, though if proper means were taken to guard against cholera, and if the relative price of corn and hogs should justify it, the number of brood sows kept might be larger than this. Assuming that five hogs will be needed for home use, this would permit a sale of fifteen 200-pound hogs a year.

Such a farm could maintain 150 hens easily, with very little cost. These hens, if handled with a little intelligent care, should easily bring in a dollar apiece annually, in addition to poultry products used on the farm.

Such a complement of live stock as outlined would consume most of the corn, all the corn and cowpea fodder, the miscellaneous forage crops, and a portion of the straw. The remainder of the straw should be used very liberally for bedding for the live stock.

An organization such as this could be established on a farm of 160 acres, provided there is not over 10 acres of waste land, which, in the nature of the case, must be devoted to the growing of timber. This would permit, in addition to the 117 acres of crops, 26 acres

of permanent pasture, 5 acres for roads and fences, 2 acres for yards and lots, and 10 acres for woods. If much of the farm is rough land, the area would have to be proportionately larger.

Such a farm would be particularly advantageous for a farmer with one or two growing boys large enough to take part in the farm work; also for the farmer who is growing old and is no longer able to make a full hand at the heavy work on the farm. With one dependable hand hired by the year and the use of four-horse implements as far as practicable, the hired man could do nearly all the field work of such a farm, leaving the owner to look after the live stock, the strawberries, garden, and orchard, and to keep in repair the buildings, fences, implements, etc. The farm family could tend the poultry.

Such a farm would have the equivalent of about eighteen 1,000-pound animals. These animals would produce approximately 180 tons of manure in a year. The bulk and value of this manure could be increased greatly by the liberal use of straw as bedding. By proper management 100 tons of mixed manure and straw could be distributed on the fields every year. This would give an average of $2\frac{1}{2}$ tons for every acre of corn on the farm. Such use of the manure should have a very important influence in keeping up the fertility of the soil.

The wheat straw produced on this farm should be returned to the land in some way. As much of it as possible should be used as bedding for the farm animals, and in this way be put into the manure. This gives a chance to rot the straw before it is put back on the land, a very important matter, since partially rotted straw is much better for the land than fresh straw. Such of it as can not be used in this way may be scattered directly on the fields. A very thin coating of straw can be spread upon wheat during the winter. A better plan is to scatter straw in the fall of the year on land that is to be devoted to corn the next year and then disk it into the soil before winter sets in.

Each field will be in wheat three times in succession, the first time following corn. After the third crop of wheat has been harvested from the field it would be a good plan to sow some crop immediately. It would not be necessary to plow for this crop, but it would be advisable to run a disk harrow over the land. The crop might consist of corn or sorghum sown thickly, or it might be cowpeas or soy beans. At some convenient time in the late summer or early winter this crop should be plowed under. It might be pastured for a while before plowing. By using all these means of adding humus-making material to the soil, and then by the use of such fertilizers for wheat as local experience has proved to be most profitable, the yields of corn and wheat might easily be raised considerably above the average for the region.

LEGUMES.

From the standpoint of the farmer the most important characteristic of the legume crops, like clover, alfalfa, cowpeas, soy beans, etc., is the fact that each of them has the power of supporting in their roots a kind of bacteria that gets nitrogen out of the air, and thus crops of this kind enrich the soil in nitrogen—one of the most important elements of soil fertility.

Clover has been grown more or less in southwestern Missouri since the country was settled. In some localities it is well established and holds a place in the cropping system. But, generally speaking, the experience of the farmers of this section with the clover crop has not been satisfactory. In those regions where clover is grown regularly the common practice is to sow it in the spring on winter wheat or with some spring grain crop. This method has been tried many times by the farmers of this region, sometimes with complete success but more often with more or less complete failure. The trouble is that in many years the moisture is not sufficient for both the grain crop and the young clover crop, and the clover dies either before the grain crop is harvested or immediately thereafter.

A few farmers of this general region have been successful with clover by sowing it alone in the spring on well-prepared land. It makes a small crop the first year and a good crop the second year: but this takes two years' use of the land in order to get a crop of clover, which is not satisfactory to most farmers. If the farmer could depend upon securing a good stand of clover by sowing it in the spring on winter wheat, the clover crop undoubtedly would be standard in this section; but since this method is not dependable, clover is of very small importance here.

Most of these farmers have tried alfalfa. Generally speaking, the crop has failed, though a few farmers in these two counties have grown it with greater or less success. It can not be recommended generally as a field crop here, though it is probable that with a little special attention a few acres of it might be grown to advantage on almost any farm. In this region it should be sown only on the richest land, and the land should be thoroughly limed and thoroughly inoculated either with dirt from an alfalfa field or from a sweet clover patch or with pure cultures of the alfalfa bacteria. If then the land is well prepared and harrowed frequently enough to kill the weed seeds in the surface, and the alfalfa sown at a time when the land has proper moisture in it late in the summer or in very early fall, the chance for a good stand of alfalfa is fair.

The only legume which is grown from time to time with success by practically all these farmers is the cowpea. All the land in this region appears to be inoculated for this crop; that is, it contains the

particular kind of bacteria that the cowpea crop requires in order to thrive. A few farmers grow a considerable acreage of cowpeas for hay. Relatively few plant cowpeas in their cornfields. But in view of the fact that the system of farming which prevails in this region is one which does not maintain soil fertility, it is advisable for farmers generally to give more attention to the cowpea crop. It has already been suggested that it is a good plan to plant the cowpeas with the corn at the time the corn is planted. When this is done the roots of the cowpeas will leave considerable nitrogen in the soil, and the cowpea vines, which will be harvested with the corn fodder, will ultimately be converted into manure and returned to the soil. In case the corn is not to be cut for fodder, it is just as well to plant the cowpeas in the corn at the time of the last cultivation of the corn and then plow the vines under either early in the winter or the next spring. This, of course, is not practicable where wheat is to follow corn, but it can be done where corn or any other spring crop follows corn.

The soy-bean crop deserves more attention than it has received from farmers in this region. It has been tried frequently here, but not always with satisfactory results, for the reason that some farmers do not understand its requirements. Cowpeas have been grown in America for 150 years, and the soil all over the eastern half of the United States appears to be thoroughly inoculated for this crop. Soy beans, on the other hand, were brought to this country rather recently from Japan and Manchuria. They will not thrive unless the soil has the proper kind of bacteria in it, and these bacteria are not yet generally spread over the country. Hence, in order to grow soy beans successfully the soil must be inoculated for them.

There are several methods of inoculating the soil for soy beans. Soy-bean seed carry some of the inoculating material, but very little. If a small patch be planted to soy beans for two or three years in succession it will become well inoculated, and the soil from this patch may then be used for inoculating any other part of the farm where soy beans are to be planted. Another method is to moisten the soy-bean seed with water in which a little glue has been dissolved, sprinkle a little dirt from a soy-bean field over the seed, let it dry, and then plant the seed. Great care must be used in this method not to let the sun shine on the seed, for sunlight kills these bacteria very quickly. Another method is to use the pure cultures of the soy-bean bacteria such as those furnished by the United States Department of Agriculture.

Soy beans have several very distinct advantages over cowpeas. The most important is that they ordinarily yield from half as much again to twice as much seed per acre as do cowpeas. They can be made into hay more easily than cowpeas, and this hay, if fed with a

proper mixture of coarser material, such as corn fodder, is just as good as cowpea hay. Another very important point is that soy beans can be used for hog pasture at any time, for hogs will eat the leaves on soy beans greedily, while cowpeas are good hog pasture only when the seed is ripe. Soy beans are also excellent human food.

The subject of legumes is discussed here somewhat in detail because of the great need for means of building up soil fertility in this region. In view of the fact that clover is not satisfactory, it is believed that it would be very distinctly advantageous for these farmers to sow cowpeas or soy beans, or at least some crop that will make a growth that can be turned under after wheat that is to be followed by corn.

TENURE.

One hundred and thirty-two of the farms studied in this survey were operated by their owners; 88 were operated by owners renting additional land; 24 were operated by tenants. Of 30 of the larger farms, part was rented out, the owner having more land than he could operate satisfactorily. Of the 88 owners renting additional land, 53 were in the group of grain and live-stock farmers and 18 in the group of grain farmers. Exactly half of the tenants were on grain farms, 9 on grain and live-stock farms, 2 on grain and fruit farms, and 1 on a fruit farm. Less than 10 per cent of the farms in this region are operated by tenants. This is much lower than the general average of tenant farming in the Middle West, or for that matter in any large area in the country. This is due partly to the average small incomes made on farms in the region. A tenant farm ordinarily must contribute to the living of two families. Hence tenant farming is not common outside of the plantation system in the South except where the farms are fairly large and productive.

Table 10 gives some interesting facts about land tenure in this region.

TABLE 10.—*Relation of tenure to profits (132 farms near Monett, Mo.).*

Item.	Owners.	Owners, renting addi- tional.	Owners, part rented out.	Tenant.	Landlord.
Number of farms.....	132	88	30	24	24
Crop area..... acres..	76.5	87.8	89.2	83.4	83.4
Capital..... dollars..	9,130	6,519	10,370	1,061	7,144
Farm income..... do..	765	748	603	477	232
Percentage on investment ¹ per cent..	5.2	5.8	3.5	18.7	3.2

¹ After deducting operator's labor from farm income.

Tenant farms, on the average, have a larger crop acreage than owner farms. Tenants, with a capital only one-ninth that of the owners, obtained an income more than half as large. By deducting

from the farm income the value of the farmer's labor and converting the remainder into percentage of the investment of the operator, the results shown in the last line of this table are obtained. The average income on the investment of owners is 5.2 per cent. Farmers who own some land and rent other land have only about two-thirds as much capital as those who own all their land, but they make 5.8 per cent interest on their capital. Those farmers who have more land than they can till properly and rent part of it out make only $3\frac{1}{2}$ per cent on their investment. The tenant, whose capital is all invested in live stock, implements and machinery, and other working capital, makes, in addition to his wages, 18.7 per cent interest on his investment. The owners of the tenant farms make 3.2 per cent net income after deducting their expenses.

The facts in this table are of interest to the young man who is just starting out with a very small amount of capital. They indicate that his wisest course is to farm a few years as a tenant, for by so doing he can make more money than if he invested his small capital in land.

TABLE 11.—*Relation of a given amount of capital to farm income of owners and tenants (220 farms near Monett, Mo.).*

Capital group.	Owners.			Tenants.		
	Number.	Farm area.	Farm income.	Number.	Farm area.	Farm income.
\$500 and less.....				3	52	\$337
\$501-\$1,000.....				10	99	363
\$1,001-\$2,000.....				9	122	436
\$2,001-\$4,000.....	23	54	\$337	2	317	1,442
\$4,001-\$6,000.....	50	72	441			
\$6,001-\$8,000.....	32	94	613			
\$8,001-\$10,000.....	38	131	982			
\$10,001-\$15,000.....	54	156	1,135			
Over \$15,000.....	23	250	1,545			
All farms.....	220	123	834	24	120	447

This fact is brought out still more strikingly in Table 11. Considering only owners and tenants, three farmers are found with \$500 or less invested. These are all tenants farming an average area of 52 acres and making a net income of \$337. In the next group are 10 farmers having a capital of \$500 to \$1,000, operating farms averaging 99 acres in area and making incomes of \$363. These are all tenant farmers. In the next group 9 farmers, with capital of from one to two thousand, are operating farms of 122 acres and obtaining a net income of \$436. It is significant that these also are tenant farmers.

In the next group, with \$2,000 to \$4,000 capital, are 25 farmers. All but two of them have bought small farms. Those who have bought farms are making incomes averaging \$337. The two who

have remained tenants are making incomes averaging \$1,442. Beyond this point the desire for economic independence and other advantages that accrue from the ownership of land becomes so strong that every farmer is an owner. It will be noticed that among the farms included in this study just as soon as the average income rises to a point which represents a satisfactory standard of living from owner operation tenantry ceases.

Another factor is involved here. The two farmers in the fourth group who remained tenants are operating farms averaging 317 acres in size. These farms are almost too large for the managerial ability of the average man. Hence the man on these farms who has more than \$4,000 worth of capital finds it difficult to utilize all his capital as a tenant and very naturally invests it in land. The lesson is clear, however, for the young man with a small capital. For a few years at least it will be distinctly to his financial advantage to rent a good farm as large as his capital will permit. When he has saved enough to make a first payment on a farm large enough to permit a good standard of living, he then may well contemplate becoming an owner, and it is desirable from the standpoint of the public welfare that he do so.

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BULLETIN No. 634

Contribution from the Bureau of Chemistry
CARL L. ALSBERG, Chief



Washington, D. C.

PROFESSIONAL PAPER

April 4, 1918

A PHYSICAL AND CHEMICAL STUDY OF THE KAFIR KERNEL.

By GEORGE L. BIDWELL,

Chemist in Charge, Cattle Food and Grain Investigation Laboratory.

The grains of nonsaccharine sorghums are becoming very important commercially. Although heretofore largely limited in their use to feeding farm animals, they are now being employed in increasing amounts for human food, a matter which has been studied by the Office of Home Economics of the Department of Agriculture.¹ Furthermore, the attention of manufacturers of alcohol and starch is being turned to these grains. As a basis for a process which would utilize nonsaccharine sorghums, probably one of the cheapest sources of starch, in the manufacture of starch and feedstuffs, a study was made in the Bureau of Chemistry of the physical characteristics and chemical composition of the kafir kernel, and the various parts into which it might be separated by milling. Kafir was selected because it is typical of this class of grains, and economically as important as any of them. Therefore a sample of Dawn kafir (Dwarf Blackhull), C. I. 340, was obtained from the Bureau of Plant Industry for this purpose. This sample was grown at the Cereal Field Station, Amarillo, Tex., in 1915, and is the same grain as that used in the food experiments.¹

The kafir kernel shows some interesting physical characteristics. It is obovoid, or broadly ellipsoid, convex on the outer or dorsal surface, and somewhat flattened on the inner or ventral surface. It might be considered as developed from a sphere by first rolling it in such a way as to lengthen one diameter slightly, then flattening it on one side. The tip is more or less pointed. Beneath the tip is the hilum, or point of attachment of the seed. The outer end usually is rounded, but often bears a tiny, double, claw-like point. The endosperm, the main portion of the kernel, is horny without, inclosing a white, starchy mass. The germ lies in a depression in the endosperm, near the tip of the seed. The kernel is covered with a thin skin or bran coat, dirty white in color, spotted or blotched with dark reddish brown or black. Figure 1 shows the interior structure of the seed.

¹ U. S. Dept. Agr. Bul. 470, and Farmers' Bul. 559.

Fifty kernels of kafir were measured with a micrometer in three directions. As a kernel of kafir lay on a flat surface the vertical diameter was called the thickness; the shorter horizontal diameter, the width, and the long diameter, the length. The maximum and minimum as well as the average dimensions are shown in the following table:

TABLE I.—Measurements of 50 kernels of dwarf black-hulled white kafir, in millimeters.

Dimension.	Maximum.	Minimum.	Average.
	<i>Mm.</i>	<i>Mm.</i>	<i>Mm.</i>
Thickness.....	2.74	2.16	2.46
Width.....	3.71	2.95	3.33
Length.....	4.57	3.07	3.90

One thousand kernels of this sample weighed $23\frac{1}{2}$ grams. Therefore, one kernel weighs on an average 0.0235 gram. From the

measurements recorded in the table the average volume of these kernels was calculated and found to be 16.78 cubic millimeters and the surface of such a grain 32.98 square millimeters.

One hundred and fifty-seven grams of kafir were treated with sufficient water to loosen the bran and then separated with a dissecting needle into bran, germ, and endosperm. It was found that only enough water was required and with two hours' standing in this condition the bran could be removed easily. Regardless of the time of soaking, there was always some difficulty in getting the bran loose at the tip. The

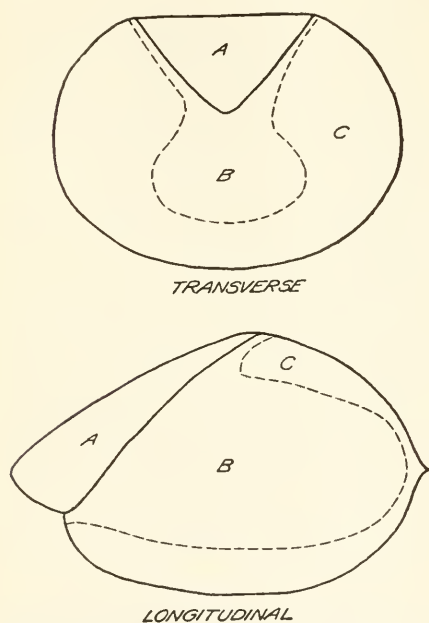


FIG. 1.—Sections of kafir kernels showing (A) germ, (B) starchy endosperm, (C) horny endosperm.

separation of the germ and endosperm at that point was also difficult. For that reason there is probably a small amount of starch mixed with the germ, but special care was taken to keep this as small as possible.

It was found that 6.1 per cent, by weight, of the kafir kernel was bran; 10 per cent was germ; 83.9 per cent was endosperm. This would amount to 1.02 cubic millimeters of bran; 1.68 cubic millimeters of germ; 14.1 cubic millimeters of endosperm, if we assume that those three substances have practically the same specific gravity. On the same assumption the thickness of the bran would average 0.031 millimeter. Surrounding the endosperm lies a very friable, more or less granular layer which seems to carry a large amount of coloring matter. This

colored layer does not cover the germ but passes between it and the endosperm, as is evidenced in the very highly colored kernels where the germ is seen clearly through the bran by appearing lighter in color than the endosperm. In a small proportion, possibly 1 per cent of the kernels, this coloration was very pronounced. An extended study of this color was not made, but in extracting ground kafir in a paper capsule, both with ether and with chloroform, a red coloration was noted upon the lower part of the capsule, and this coloring matter was also noticeable in the solutions during the crude fiber determination. It was thought that this coloring matter might be associated with tannin, but tests for this substance failed to show its presence. Additional tests by the Pharmacognosy and Leather and Paper Laboratories of this bureau confirmed these results.

The next step in this work was the determination of the composition of the kafir kernel and of the various products into which it had been separated by the method described above. It was found that by grinding the endosperm in a small coffee mill a rough separation of starchy and horny endosperm could be made. The material was reground through the mill several times until it would all pass a 20-mesh sieve; then the material that would pass a 40-mesh sieve was called "starchy endosperm" (6), and the part that remained on the 40-mesh sieve was called "horny endosperm" (7). No. 6 was floury in appearance and No. 7 had the appearance of sand.

An examination of sections of the seeds shows that the starchy part lies in the center of the endosperm, surrounded on all sides by the horny endosperm, except that it reaches the under side of the germ.

The following samples were analyzed:

- (1) Sample of whole kafir.
- (2) Sample of whole kafir moistened and allowed to stand over night, dried and ground for analysis in order to approximate but somewhat intensify any changes which might be caused by the moistening of the various parts.
- (3) Pure endosperm, as defined above.
- (4) Pure germ, as defined above.
- (5) Pure bran, as defined above.
- (6) Starchy endosperm, as defined above.
- (7) Horny endosperm, as defined above.

TABLE II.—*The composition of kafir and its various parts on a water-free basis.*

Sample.	Per cent of whole kafir.	Ash.	Ether extract.	Crude protein (N×6.25).	Crude fiber.	Nitrogen- free ex- tract.	Pento- sans.	Starch.
		<i>Per cent.</i>	<i>Per cent.</i>	<i>Per cent.</i>	<i>Per cent.</i>	<i>Per cent.</i>	<i>Per cent.</i>	<i>Per cent.</i>
(1) Whole kafir.....	100.0	1.8	4.1	12.7	1.8	79.6	3.3	61.9
(2) Whole kafir moistened and allowed to stand over night.	100.0	1.7	4.2	12.7	1.8	79.6	3.8	63.2
(3) Pure endosperm..	83.9	.3	.7	12.7	.8	85.5	1.9	69.3
(4) Pure germ.....	10.0	13.2	31.5	19.3	3.8	32.2	6.1	-----
(5) Pure bran.....	6.1	2.0	6.8	4.8	16.2	70.2	18.4	-----
(6) Starchy endo- sperm.....	35.0	.3	.8	10.1	.8	86.5	1.9	70.4
(7) Horny endosperm	48.9	.3	.7	13.7	.7	83.8	1.6	68.8

An attempt to determine galactans on these samples was made, but the results are omitted, since in no case were the results over 1 per cent and on attempting to recover the mucic acid from the precipitates none was found.

The methods of analysis were those of the Association of Official Agricultural Chemists, as given in the journal of that association. The starch was estimated by the diastase method.

The results on sample No. 2 show that no change which could be detected by the analyses made was caused by soaking.

These analyses may well be compared with those of different parts of the corn kernel made by Hopkins, Smith, and East ¹ in their study of the structure of the corn kernel. In this work three samples of corn differentiated by the amount of protein contained, namely, low, medium, and high, were examined. The one containing the medium amount of protein has been selected for comparison with kafir, since it is nearest the normal. They divided the horny endosperm into two parts, "horny gluten" and "horny starch." These analyses have been combined so as to compare with kafir "horny endosperm." They also divided the starchy portion into "crown starch" and "tip starch." These have also been combined to correspond to kafir "starchy endosperm."

The following table compares the parts of the kafir kernel with the corresponding parts of the corn kernel:

TABLE III.—*Comparison of kafir and corn separations.*

Material.	Kernel.	Ash.	Ether extract.	Protein.	Carbohydrates.
	<i>Per cent.</i>	<i>Per cent.</i>	<i>Per cent.</i>	<i>Per cent.</i>	<i>Per cent.</i>
Corn hulls.....	7.39	0.79	0.89	3.96	94.36
Kafir bran.....	6.1	2.0	6.8	4.8	86.4
Horny endosperm:					
Corn.....	55.59	.44	1.15	11.85	86.56
Kafir.....	48.9	.3	.7	14.5	84.5
Starchy endosperm:					
Corn.....	25.49	.26	.24	7.84	91.66
Kafir.....	35.0	.3	.8	11.66	87.3
Germ:					
Corn.....	11.53	9.90	34.84	19.80	35.46
Kafir.....	10.0	13.2	31.5	19.3	36.0

The figures for percentage of the various parts of the corn kernel are taken from Table III on page 87 of the Illinois bulletin, and those for the composition are taken from Table I, on page 83.

In comparing the analyses of kafir bran with corn bran, or corn hulls, the most noticeable difference is in ether extract. The kernel of corn is developed under the protection of husks, but the kernel of kafir grows in a somewhat exposed condition. When measuring the kernels it was found that they seemed slippery and it was difficult to hold them with a forceps. This led to the belief that the kernel

¹ Illinois Agr. Exp. Sta. Bul. 87, Aug., 1903, p. 83.

might be covered with a protective film of some waxy or fatty material and it seemed worth while to ascertain the nature of it. A large quantity of whole kafir therefore was washed rapidly with ether and chloroform. This removed soluble material to the extent of one-tenth of 1 per cent. On examination this was found to contain 16 per cent of unsaponifiable matter, which indicates that the kernel is probably covered with a film of waxy material.

According to Baird¹ the amount of unsaponifiable matter in kafir fat is 1.7 per cent. The kafir fat studied by him, however, was a gasoline extract of the entire grain, and he described it as having a consistency like vaseline although somewhat harder. In this investigation the ether extract from the pure bran was found to be somewhat harder than that described by Baird, and it was found that it hardened rapidly in the fat flasks and cracked from shrinking. The ether extract from the germ, on the other hand, was found to be a clear yellowish oil. The kafir fat described by Baird was a mixture of the solid extract from the bran and the liquid extract from the germ, as well as a small amount from the endosperm, and thus the material had the consistency he describes.

In studying the analysis of the two portions of the endosperm of kafir and corn it will be noted that, though the protein is higher in the kafir, the horny endosperm in each case has more protein than has the starchy endosperm. The germs of corn and kafir are very similar in composition.

Table IV gives the distribution of the various constituents among the different parts of the kernel expressed in percentages of the total amount of each constituent in the entire grain:

TABLE IV.—*Distribution of constituents.*

Material.	Whole kafir.	Ash.	Ether extract.	Crude protein (N×6.25).	Crude fiber.	Nitrogen- free ex- tract.
	<i>Per cent.</i>	<i>Per cent.</i>	<i>Per cent.</i>	<i>Per cent.</i>	<i>Per cent.</i>	<i>Per cent.</i>
Germ.....	10.0	77.9	75.2	15.5	19.1	4.1
Bran.....	6.1	7.2	9.9	2.3	49.7	5.5
Starchy endosperm.....	35.0	6.2	6.7	28.4	14.1	38.4
Horny endosperm.....	48.9	8.7	8.2	53.8	17.1	52.0
Whole endosperm.....	83.9	14.9	14.9	82.2	31.2	90.4

The results of this study show that corresponding parts of the kafir and corn kernels resemble each other in composition and appearance, and lead us to believe that if kafir were handled in a manner similar to that used in the preparation of corn products, kafir products might be substituted for the corresponding corn products.

¹ Oklahoma Agr. Exp. Sta. Bul. 89, June, 1910.

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UNITED STATES DEPARTMENT OF AGRICULTURE



BULLETIN No. 635



Contribution from the Bureau of Chemistry
CARL L. ALSBERG, Chief

Washington, D. C.

March 9, 1918

THE COMMERCIAL FREEZING AND STORING OF FISH.

By ERNEST D. CLARK, *Investigator in Fish and Fish Products*, and LLOYD H. ALMY, *Assistant Chemist, Food Research Laboratory*, prepared under the direction of M. F. PENNINGTON, *Chief, Food Research Laboratory*.

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FREEZING AS A MEANS OF CONSERVING THE FISH SUPPLY.

But for the fact that fish can be frozen and held in storage for months without important change in food value or flavor vast quantities of fish would go to waste, and this valuable nitrogenous food and substitute for meat would be scarce or even unobtainable, except in the smoked, salted, or canned form, during a large part of the year. The additional fact that fish properly frozen and inclosed in a protective glaze of clear ice may be shipped long distances without deterioration permits many inland communities to obtain in the winter favorite varieties taken in distant waters. Without such conservation bluefish would be on the market for only a few weeks, and then mostly in the vicinity of certain waters; salmon, unless canned or smoked, would be unknown in many sections; there would be no country-wide interchange of halibut, pike, mackerel, smelts, and other popular fish; and during the winter, when storms prevent fishing and schools of fish migrate to deep water or southward, fish of many varieties would be a costly delicacy instead of occupying their matter-of-fact place on the table.

The commercial supply of fish depends on weather conditions and on the brief periods during which certain fish appear at banks or in rivers to feed or to spawn. Much of the fish crop, therefore, is as strictly seasonal as are the harvests of most of the perishable land crops. During certain seasons fish are landed in quantities far in excess of immediate needs, and, without effective conservation, these vast temporary surpluses would go to waste. The importance of saving the surplus of spring, summer, and fall catches for later use was appreciated long before conservation by freezing became known. Each fishing season large quantities were saved, as they still are, by canning, smoking, salting, and pickling. Freezing and storage, however, has the advantage over these other methods, in that it does not alter the flavor or appearance of fish, and therefore makes available months later, in almost the natural condition, the spring or summer catches of seine or hook.

The fish-freezing plants (Pl. I, fig. 1) located at many points on our coasts and the Great Lakes, and constituting an important industry, are becoming increasingly useful as sources of nitrogenous food to make up the deficiencies in the meat supply. Their work is true food conservation. Harvests of fish, unlike land crops, add to rather than take from the fertility of our soils. Meat represents the conversion by animals of grain or other foodstuffs into another form of food. Fish, however, represent the conversion of valueless aquatic vegetation or animal material into human food, and, had merely for the labor of harvesting, they are a net gain in the food supply.

PREPARATION OF FISH.

To produce frozen fish which after several months of storage will be practically equal in food value and flavor to freshly caught fish, it is essential that they be placed in the freezing rooms as soon as possible after they leave the water. The fish should be handled as little as possible, for any bruising, breaking of the skins, or damage to fins either lessens their keeping quality or lowers the attractiveness of the fish at market. Under no circumstances should fish be allowed to become warm from the time they are caught until they are frozen. Very slight exposure to warmth causes changes in their flesh which no amount of freezing will remove.

The ideal method of freezing fish is that employed in winter in Canada and other very cold sections (Pl. I, fig. 2), where fish caught through the ice or on the edge of the ocean are allowed to freeze naturally as they leave the water. Such fish from our northern lakes, and others, like the smelt from Nova Scotia and New Brunswick, begin to freeze while they are still flopping on the ice or in the snow. These frozen fish, which commonly have twisted bodies, due to being frozen almost instantaneously while still alive, are known on the

market as "winter caught" or "naturally frozen" stock, and, when the handling subsequent to the quick freezing is such that thawing does not occur before the market is reached, they usually command a premium because of their very fine flavor. While those who freeze fish by artificial means rarely would be able to have fish delivered alive to their plants, owners of freezers should make every effort to have their fish delivered in prime condition.

LOCATION OF FREEZERS.

Fish freezers, therefore, are best located near those fishing grounds which yield a regular supply of perfectly fresh fish (Pl. II, fig. 1). If the plant is distant from the fishing ground, or if the fish can not be delivered while still cold and within three or four hours after they are taken from the water, the owner should demand that the fishermen carry in the holds of their boats cracked ice for the proper storing of the fish as they are taken. To avoid extra handling the plant should be located near the water's edge, and, if feasible, provided with mechanical conveyors which carry fish directly from the boats to the cleaning tanks (Pl. II, fig. 2).

CLEANING FISH.

Fish as they are received in the plant must be washed free from all dirt and slime in clean, cold, running water conveniently provided in long tanks. Whether the fish should be "gutted" before freezing depends upon their size and kind, and also, to some extent, upon the market to be supplied. New York and Boston, for example, prefer salmon frozen in the "round"; other sections require that the entrails be removed before freezing. In the case of bluefish and other larger fish which are heavy feeders or which eat freely of animal material, gutting before freezing seems desirable. This is true also of fish which contain much oil, especially in the liver. Fish containing much partly digested feed in the stomach or having much oil in the flesh, deteriorate more quickly than do empty or lean varieties. Gutting of smaller fish, such as butterfish, small mackerel, small weakfish, and bass, is impracticable. These fish commonly are frozen in their natural state in pans containing about 40 pounds (Pl. III, fig. 1). Larger fish, like halibut and salmon, usually are not placed in pans but are washed and frozen separately, especially on the Pacific coast, where the fish frozen are largely of these two varieties, although some black cod or "sablefish" are handled.

FREEZING FISH.

In the most successful establishments the panned fish are placed directly on the refrigerator pipes in the "sharp freezer" room the temperature of which varies from -5° to -15° F. (Pl. III, fig. 2).

These pipes are usually direct expansion pipes from the ammonia refrigerating plant. They are so arranged that they make a series of shelves one above the other, each consisting of numerous pipes. Passageways are left between each set of shelves for the convenient handling of trucks. Some plants have installed mechanical conveyors to facilitate carrying the fish to and from the fish-freezing rooms.

The operators remove the frozen fish from the pan by pouring a little cold water on the outside of the pan, which causes sufficient melting to allow the frozen fish to slip out in a block. Fish which are to be frozen separately are laid on thin metal sheets resting on the cold pipes, or they are suspended in the air from iron rods or hooks. Fish, single or iced, freeze thoroughly in from 12 to 30 hours, according to their size and the temperature of the freezing room.

FREEZING IN ICE OR IN BRINE.

The older method of freezing fish by packing them in covered pans which then are buried in ice and salt still is practiced in some districts. This plan is not adapted to freezing fish rapidly on a large scale and does not lend itself to accurate control of temperature. Methods of freezing fish in saturated salt brine, cooled to low temperatures by freezing coils, recently have been patented. The salt in brine chilled almost to its freezing point apparently does not penetrate into the fish to any great extent, and freezing is much more rapid than in air. These processes have great merit from the theoretical point of view, and appear to be adapted to commercial conditions, but as yet they have not been adopted by the trade in this country.

GLAZING.

Glazing, an important step in the freezing of fish, is designed to incase each fish or each block of frozen fish with an air-tight protective envelope or cover of clear ice. Unless glazed, the skins of frozen fish are liable to turn white and the fish themselves will shrivel because of loss of moisture which takes place even at freezing temperatures. Noses and fins of frozen fish, unless protected by glazing, are the first points to show the effect of loss of moisture. Glazing also helps to prevent the eyes of the fish from becoming opaque and shrunken and to obviate deterioration which makes the gills, which normally are bright red, darker and brownish. Glazing prevents the evaporation of the moisture from the flesh of the fish, prevents the entrance of air which tends to make the fish oils deteriorate, provides an ice surface upon which molds and fungi can not grow, and finally helps to protect the fish from mechanical injuries which mar its appearance.

For glazing, the frozen fish are taken to the glazing room, which is held at a temperature of 20° to 25° F., or just cold enough to cause thin layers of cold water to freeze rapidly. The glazers slide the frozen cakes of panned fish, or the separately frozen fish, quickly through a trough of clean, clear water held just above the freezing point. (Pl. IV, fig. 1.) This water covers the product with a thin film which in the cold air freezes instantly into a crystal-clear glaze of ice like a transparent varnish. Unless the water is changed frequently, however, it is apt to collect oils or other material from the fish which will prevent the glaze from forming evenly on all parts of the fish or give the ice coating a cloudy appearance.

Fish are passed through the water from three to five times until the several coats of glaze form a sufficiently heavy and permanent ice envelope covering the entire surface. Even before glazing the blocks of frozen fish in the pans have become solid cakes, the fish being held together by the freezing of the thin layer of water between them, and the glazing still further cements them to each other. Glazing of fish adds about 5 per cent to their weight, although this varies with the size of the fish and the number of glazings. To expedite the glazing of separately frozen fish, operators on the Pacific coast place the fish on small platforms, which are lowered by a winch into a tank of water and raised again. This process is repeated until the glaze which hermetically seals the fish and prevents deterioration is of the proper thickness.

COLD STORAGE OF FISH.

The glazed fish are taken immediately to the cold-storage rooms to be kept until sent to market. (Pl. IV, fig. 2.) These are rooms with coils of ammonia or brine pipes attached to walls and ceilings, but not arranged in the form of shelves, as in the freezing rooms.

The subject of the proper temperature for the long storage of frozen fish has been much discussed. Investigation seems to prove that ordinarily the most economical and safest temperature for holding fish is at any point from zero to 10° F., with as little variation in temperature as possible. Some plants, especially small establishments in isolated localities, try to keep their frozen fish at from -5° to $+5^{\circ}$ F., because fish held at these temperatures would not spoil quickly should an accident to the refrigerating machinery interrupt artificial refrigeration for a day or two.

In determining the temperature of the storage room, operators are cautioned not to be guided by floor temperatures alone, but to place thermometers so that readings can be taken at the top of the room, to which the warmer air naturally rises, affecting the uppermost fish. It is suggested that if the owner can not provide two or more thermometers he hang a thermometer from a pulley on the ceiling

so that he can take readings of the air at various heights, especially at and above the upper fish. Every operator, of course, understands the importance of keeping doors to cold storages closed, particularly when they open into outside air or into halls warmer than the storage rooms themselves.

PACKING FISH FOR STORAGE.

Before storage, frozen fish, especially on the Atlantic coast, commonly are placed in boxes lined with heavy Manila paper, which makes a better-looking package and gives additional protection. These boxes simplify the handling and shipping of fish, and also enable warehousemen to comply with any local laws which require that the date of entering the storage be stamped on the packages. Boxing the frozen fish before storage, by lessening the free circulation of air among the fish, helps also to prevent evaporation of the ice glaze, for ice evaporates even at freezing temperatures, as is evidenced by the gradual shrinking of a block of ice outdoors, even in zero weather. Boxed fish which have received from three to five glazings usually keep from three to five months without losing their glaze, or much longer than unboxed fish exposed to the air.

Four or five cakes of the panned fish, or 120 to 160 pounds, commonly are packed in one box, whose length and width are just large enough to take these cakes from the pans. Separately frozen fish, such as halibut, salmon, and other large fish, generally are first wrapped in a fish-wrapping paper, usually a vegetable parchment paper, and packed carefully in boxes lined with Manila paper. On the Pacific coast longer narrow boxes are used for packing halibut and salmon. While under some conditions the cheaper sorts of fish are stored in bulk, either in bins or in stacks, the boxed fish keep their glaze better and are less liable to damage from handling.

REGLAZING.

Because the glaze gradually evaporates, it is necessary, if the fish are to be kept in storage for a long time, to remove them from their boxes and reglaze them at intervals of from three to four months. Reglazing of fish stacked or kept in bins is somewhat more difficult. A method occasionally followed in reglazing such fish is to use a hose with a special spray nozzle, similar to that employed in white-washing. The nozzle plays a finely-divided stream of clean water on the piles of frozen fish, and this, freezing rapidly, reglazes them more or less satisfactorily. The glaze naturally evaporates most rapidly from the outer surface of the pile most exposed to air, and these parts fortunately are most accessible to the reglazing spray.

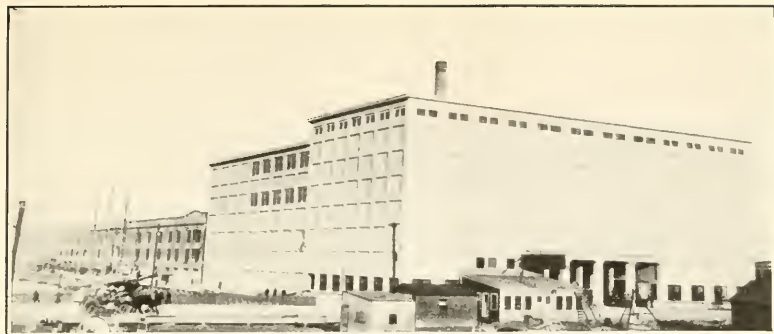


FIG. 1.—THE LARGEST FISH FREEZER IN THE UNITED STATES.

The State of Massachusetts built this freezer, which has a capacity of 15,000,000 pounds of frozen fish.



FIG. 2.—WINTER-CAUGHT, OR NATURALLY FROZEN, FISH.



FIG. 1.—NEWLY CAUGHT FISH CARRIED BY WAGON FROM BEACH TO FREEZER.



FIG. 2.—CONVEYOR CARRYING FISH FROM ICE HOLD OF BOAT TO FREEZER.



FIG. 1.—PANNING FISH, PREVIOUSLY WASHED IN LONG TANK BESIDE WHICH THE MEN ARE STANDING.



FIG. 2.—SHARP FREEZER ROOM.

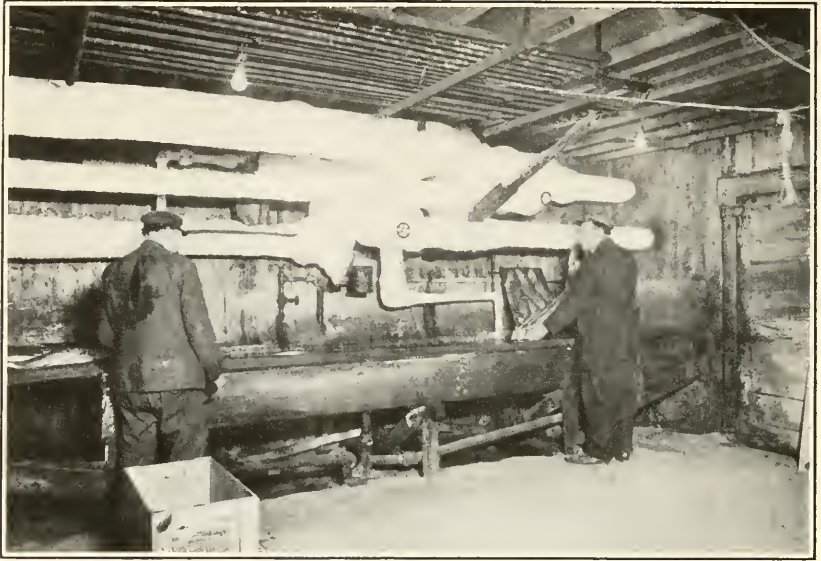


FIG. 1.—PUTTING FISH IN ICE ENVELOPES.



FIG. 2.—COLD-STORAGE ROOM. PILES OF FROZEN HALIBUT READY FOR BOXING AND SHIPMENT.

PERIOD OF STORAGE.

The average period of storage for fish, as shown by investigation and statistics, is approximately only eight months. Much frozen fish, however, is sold within a few months after it is stored, and only rarely are batches of fish held as long as twelve months. Careful analysis of fish properly stored for such periods fails to indicate any important change in the food value of the fish, or to reveal any noticeable alteration in the flavor. To study in a practical way the effect of freezing storage on flavor, one of the writers¹ arranged a test with a large group of people who were unaware that they were being used for subjects. These people were served a half portion of fresh fish (mackerel) and a half portion of the same species of fish properly frozen and stored for nine months. The average individual was unable to distinguish between the fresh fish and the frozen fish, and a number expressed a preference for the frozen lot.

In an effort to determine the natural storage limits for frozen fish, the department's investigators recently held frozen fish for twenty-seven months under close observation in a Government experimental freezer. Elaborate analyses of the fish at various time intervals and at the end of this period failed to show changes which rendered them at all unsuitable for food, or to indicate any important differences in chemical composition between these fish and fresh fish or fish stored for shorter periods. The actual period for which any batch of fish will be held in storage depends, of course, largely upon the market conditions. Only under very unusual circumstances are frozen fish held for more than one year, because the season of fresh fish of any particular species will recur in ten or twelve months, and frozen fish bring lower prices than fresh fish. Frozen fish must be marketed before fresh fish again become plentiful on the market. Other deterrents against holding fish for any great length of time are the cost of refrigeration, labor, and reglazing, insurance during storage, interest on capital, and other factors which promote withdrawal from storage as soon as a favorable market can be obtained. The legal limit on the storage of fish in several States varies from nine to twelve months, although in certain States extensions can be secured upon application to the proper authorities. Observations show, however, that only under very abnormal conditions and in unusual seasons is there either any necessity for or commercial advantage in holding fish longer than nine or ten months.

FOOD VALUE OF FROZEN FISH.

Fresh fish, properly frozen, glazed, and held at low temperatures for nine months or a year show no important changes in composition to the food chemist or bacteriologist. No lessening of palata-

¹ From unpublished investigations of L. H. Almy.

bility noticeable to the average housewife occurs. This is to be expected, as freezing, unlike most other preservative measures, takes nothing from the fish and adds nothing to it except a thin outer covering of ice which soon melts upon thawing the fish for consumption. The low temperatures at which the flesh is held in storage are well designed to prevent chemical or other changes over a number of months. Freezing, however, merely holds the fish in the condition in which it entered the freezing room. Cold can not restore freshness to old fish nor overcome deterioration from careless handling or exposure to warmth. The freezer can deliver fish practically as good as but not better than that which it receives.

To determine the behavior of fish under storage the Bureau of Chemistry held fish for the excessively long period of twenty-seven months in cold storage under its control. At different times sample lots of fish were withdrawn and analyzed. These studies showed no significant difference in composition between the frozen fish and fresh fish of the same species. Of special interest is the fact that no loss of those nitrogenous constituents which give to fish its chief food value was noted.

According to these analyses, the process of freezing and storing causes no appreciable chemical change in those constituents upon which the food values are usually calculated, even when the storage is prolonged for greater periods than are necessary or profitable in commercial practice. In some cases the chemists were able to detect after storage very slight changes in the percentage of ammonia and certain other constituents. These changes, however, affect in no way the food value of the fish, and, in fact, the differences often were not as great in the same lot of fish before and after storage as they were between two individuals of the same species when analyzed in the fresh condition.

HANDLING OF FROZEN FISH AFTER STORAGE.

When frozen fish have thawed they are as perishable as fresh fish, and should be consumed as quickly as possible. Even partial thawing lessens greatly the perfect protection of glazing and hard freezing. Retailers, therefore, should make every effort to have their frozen fish reach them hard frozen with glaze unimpaired. After the fish reach them the retailers should make very effort to keep them hard frozen and glazed until they are actually sold. This best can be accomplished by ordering frequently and not in excess of immediate sale. Customers should be encouraged to buy fish in the hard-frozen state, either to be thawed out to order by the retailer or, even better, delivered to the housewife hard frozen. She then should place them in a covered utensil in the refrigerator, or other cold place, and allow them to thaw gradually. Fish never should

be thawed by exposure to heat or by soaking in either cold or warm water. Such rapid thawing lessens their food value, and tends to dissolve out flavors essential to their palatability.

SUMMARY.

Freezing and freezer storage will hold fish for many months in the condition in which they were received, but will not repair deterioration due to previous heating or mishandling.

Freezers should accept only fish that are in prime condition. Unless delivered within three or four hours after being taken from the water, fish should be kept under refrigeration in the boats.

Rapid freezing at as low temperatures as possible is necessary in many plants in order to insure a good product and to handle receipts as they arrive.

Glazing by inclosing the fish in an envelope of ice prevents loss of moisture, protects the fish from molds and bacteria, and makes them less subject to mechanical injury. Fish to be stored for more than three to five months should be reglazed occasionally, as in time the glaze evaporates, even at low temperatures.

The most economical temperature for storing fish is probably at some constant temperature between 0° and $+10^{\circ}$ F., although some freezers hold that lower temperatures tend to delay evaporation of the glaze.

Boxing fish before storage helps to prevent loss of glaze, and protects the product from mechanical injury.

Properly frozen fish reach the retailer in excellent condition. He should keep them hard frozen until they are sold. The practice of thawing fish by warming or in water greatly lessens their food value and flavor.

Chemical analyses show no significant changes in fish held twenty-seven months, or for a period much longer than would be necessary or profitable in storing fish commercially.

PUBLICATIONS OF THE U. S. DEPARTMENT OF AGRICULTURE RELATING TO REFRIGERATION.

PUBLICATIONS AVAILABLE FOR FREE DISTRIBUTION BY THE DEPARTMENT.

- Study of Preparation of Frozen and Dried Eggs in Producing Section. (Department Bulletin No. 224.)
- Shrimp, Handling, Transportation, and Uses. (Department Bulletin No. 538.)
- Studies of Poultry from Farm to Consumer. (Chemistry Circular No. 64.)
- Practical Suggestions for Preparation of Frozen and Dried Eggs, Statement Based on Investigation Made in Producing Section During Summer of 1911. (Chemistry Circular No. 98.)
- Supplementing our Meat Supply with Fish. (Separate 623 from Yearbook 1913.)

PUBLICATIONS FOR SALE BY THE SUPERINTENDENT OF DOCUMENTS, GOVERNMENT PRINTING OFFICE, WASHINGTON, D. C.

- Changes in Fresh Beef During Cold-Storage, Above Freezing. (Department Bulletin No. 433.) Price, 10 cents.
- Preliminary Study of Effects of Cold-Storage on Eggs, Quail, and Chickens. (Chemistry Bulletin No. 115.) Price, 40 cents.
- Bacteriological Study of Shell, Frozen, and Desiccated Eggs, Made Under Laboratory Conditions at Washington, D. C. (Chemistry Bulletin No. 158.) Price, 10 cents.
- Handling of Dressed Poultry a Thousand Miles from Market (Separate 591 from Yearbook 1912.) Price, 15 cents.
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UNITED STATES DEPARTMENT OF AGRICULTURE
BULLETIN No. 636

OFFICE OF THE SECRETARY

Contribution from the Office of Farm Management, W. J. SPILLMAN, Chief
(In cooperation with the Office of Horticultural and Pomological Investigations)

Washington, D. C.



May 10, 1918

**COST OF PRODUCTION OF APPLES
IN THE PAYETTE VALLEY, IDAHO**

A DETAILED STUDY OF THE CURRENT COST FACTORS
INVOLVED IN THE MAINTENANCE OF ORCHARDS AND THE
HANDLING OF THE CROP ON 38 REPRESENTATIVE BEAR-
ING ORCHARDS, PAYETTE DISTRICT IN WESTERN IDAHO

By

S. M. THOMSON, Scientific Assistant
G. H. MILLER, Assistant Agriculturist

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May 10, 1918

COST OF PRODUCTION OF APPLES IN THE PAYETTE VALLEY, IDAHO.

A detailed study of the current cost factors involved in the maintenance of orchards and the handling of the crop on 38 representative bearing orchards, Payette district in western Idaho.

By S. M. THOMSON, *Scientific Assistant*, and G. H. MILLER, *Assistant Agriculturist*.

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The cost studies upon which this bulletin is based were made during the year 1915 in an intensive commercial apple district in the vicinity of Payette, Idaho (see Fig. 1). The number of commercial apple orchards of bearing age in this region was very limited, so that but 38 detailed and accurate records could be obtained. These are typical of the region, however, and present data which fairly illustrate apple-growing conditions in this region.

SUMMARY OF RESULTS.

Following is a brief résumé of the more important averages brought out by this study:

Size of 38 farms studied, 53.39 acres.

Size of bearing apple orchard, 11.33 acres.

Investment per farm, \$20,689.62.

Investment per acre of bearing apples, \$613.16.

Trees per acre, 63.34.

Annual yield per acre, 337 boxes.

Net labor costs, \$103.40 per acre, \$0.3068 per box (43.14 per cent of total annual net cost of production).

All other costs, \$136.25 per acre, \$0.4043 per box (56.86 per cent of total annual net cost of production).

Total annual net cost of production, \$0.7111 per box.

NOTE.—Acknowledgment is due to the Office of Horticultural and Pomological Investigations of the Bureau of Plant Industry for material assistance in the preparation of this bulletin; also to Mr. J. Clifford Folger, who aided in securing the necessary data.

In the light of the facts developed the following conclusions have been drawn as to the business of the farms studied:

The stability of the agriculture of these farms is due to the fact that, in the main, they have been developed along more or less diversified lines.

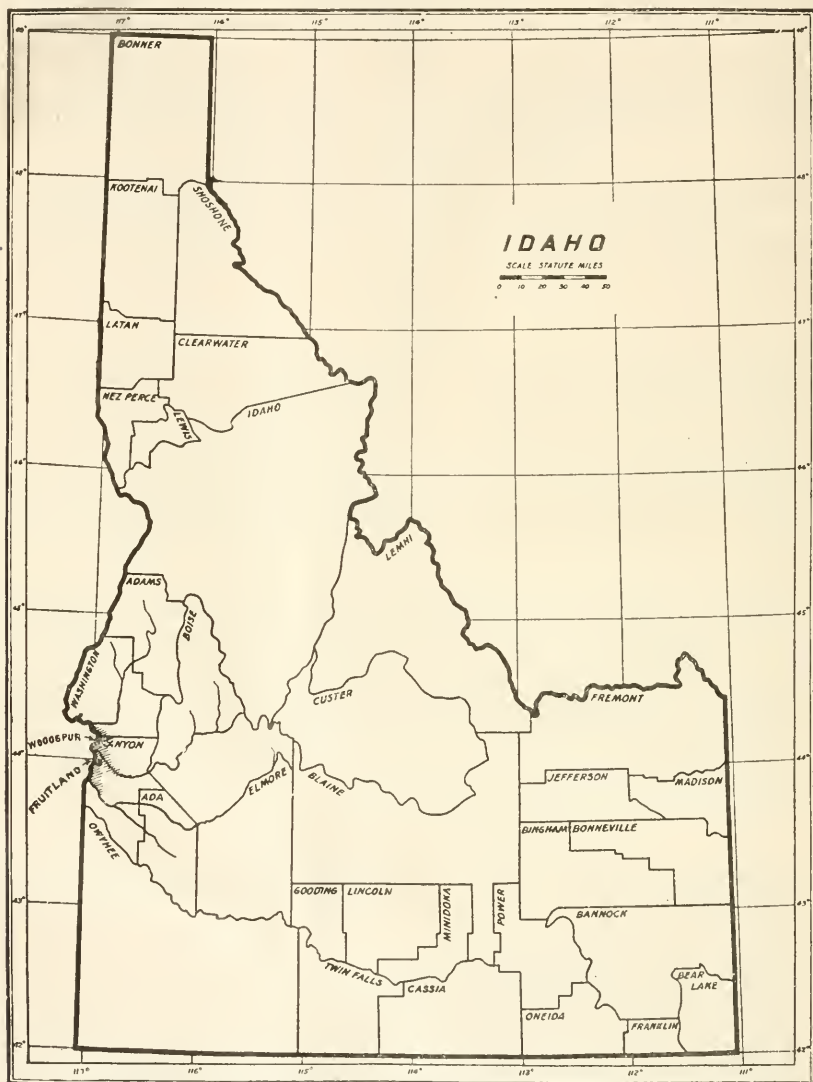


FIG. 1.—Map showing the State of Idaho and the location of the Payette fruit region.

Although the specialized fruit ranches may be the more successful in some years, the general and more diversified farms are the more successful on the average of a series of years.

Both average price and average cost of production for the region are kept below the level of those of many other apple-growing regions by the presence of a number of poorly cared for orchards producing low-grade apples.

Proper soil, good drainage, and a site not subject to frost danger are essential to the success of the apple industry on these farms.

Investment in land, yield, quality of fruit, soil, climate, and price received for fruit are all important limiting factors in the production of fruit and should be considered carefully by the present or prospective fruit grower.

Though these conclusions are advanced as applying only to the 38 farms studied, it is believed that they will apply in large measure to the Payette fruit region as a whole.

LOCATION AND EXTENT OF DISTRICT STUDIED.

The Payette, apple-growing section is located near Snake River, in the extreme northwestern part of Canyon County, on the Oregon Short Line Railway. Canyon County is in western Idaho, about 150 miles north of the Nevada line. (See fig. 2.) The elevation at Payette is 2,159 feet. This is a very extensive region, the limits of which are not well defined, as fruit growing is scattered the length of the Payette Valley and also follows the Snake and Boise River valleys. The most intensive of the bearing-orchard sections, however, is located in what is known as the Fruitland district, which is a triangular bench lying between the Payette and Snake Rivers, including about 25,000 acres of irrigated land. (See Pl. I.)

Only a small portion of the bench land is devoted to fruit. Hay and grain farming is the prevailing type, and considerable live stock is raised. (See fig. 3.) The principal shipping stations are Fruitland, a station about 5 miles south of Payette, and New Plymouth, a station 12 miles southeast of Payette. The elevation of Fruitland is about 2,200 feet. The entire bench is comparatively flat, rising from the rivers on either side and forming a broad, level table. From where the Payette River empties into the Snake River, fruit continues along the east bank of that river, in scattered areas, as far north as Weiser, a distance of about 18 miles from Payette. Other shipping stations are Emmett, Parma, and Woodspur.

The estimated extent of orchard acreage in the Payette district is approximately 20,000 acres, of which 90 per cent is in apples. Prune plantings take up most of the remaining acreage. The greater part of the apple acreage has not yet come into bearing. Pears, cherries, peaches, and berries are grown only to a limited extent.

As this region is located a long way from the centers of distribution, the transportation problem is an important one. Thus the location has had much to do with the development of the type of agriculture, and many farmers have found it more profitable to feed their grain and hay to stock than to ship bulky products to distant markets.

HISTORY AND DEVELOPMENT.

The Payette Valley is an old settled region. A few ranches were taken up as early as 1849, but it was not until after 1884, when the railroad came in, that the development of the district was marked.

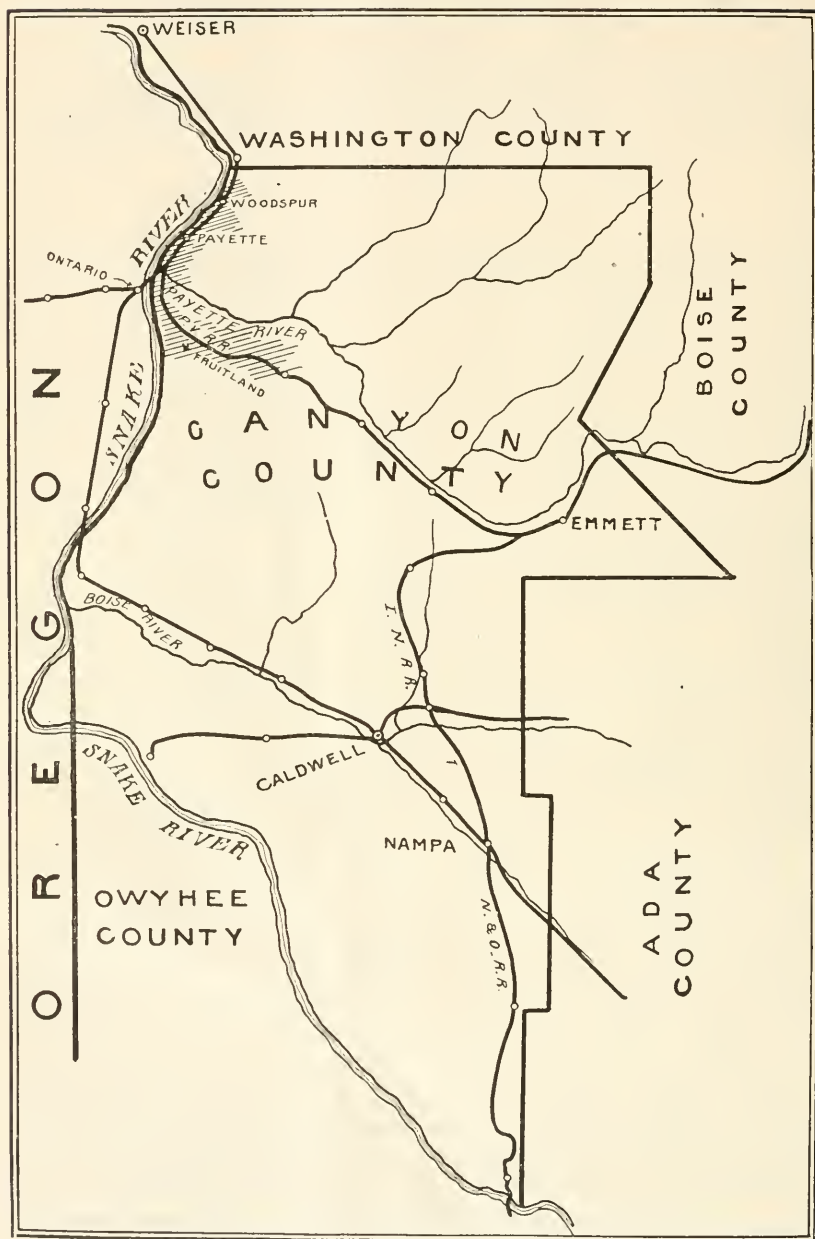


FIG. 2.—Map of Canyon County, showing the most intensive fruit area of that section.

In 1881 the first irrigation project was started. (See Pl. II.) Prior to this time the farming industry was confined largely to raising horses and cattle and growing grain for home consumption.

The history of the orchard industry in the Payette region dates from the early eighties, but it was not until about 1895 that commercial plantings of prunes and apples were made. Most of the planting has been done since 1900. During the last four or five years the planting of apples has fallen off, but prunes still are being planted in commercial quantities.

The early orchards were largely home orchards and were made up of many varieties, including Wolf River, Lawver, Ben Davis, Baldwin, and many other old varieties. The later orchards are made up largely of Jonathan and Winesap, which are the principal commercial varieties of the valley to-day. Mining towns, such as Butte



FIG. 3.—A small ranch near Fruitland showing the type of diversified farming practiced.

and Anaconda, together with the smaller settlements located nearer Payette, offered the best markets for the products of the valley in early years, but with a growth of the industry more distant markets were sought.

Many of the owners of the older bearing orchards are those who bought the land at comparatively low prices and developed it themselves. Homesteads could have been taken up in the valley as late as 1895. Much of the younger acreage of apples and a few of the older tracts are held by a class of newcomers who have settled in the valley during the last few years. Owing to frosts and occasional years of poor prices, many growers have been disappointed somewhat in the apple industry. Taking into consideration the agricultural experience of the region, it would seem that specialized fruit growing does not promise to become relatively as important as in some regions which by virtue of their location, soil, and climate are better adapted to the production of high-grade apples.

CONDITIONS.

LABOR CONDITIONS.

Labor conditions in the valley, generally speaking, are very good. Month help is often employed with an addition of day help during harvesting. The average labor rate is somewhat less than in the specialized northwest fruit districts, where labor is largely dependent on fruit, with little general farming to fill in the gaps between the busy seasons. Here labor can find employment for the entire year on account of the great diversity and kinds of farming followed. Grain, hay, stock, and fruit under both intensive and extensive types of farming are found.

At the time of this survey the labor rate on the farms studied was \$0.20 per hour for man labor and \$0.15 per hour for horse labor. The horse-labor rate is figured on the basis of the value of team labor where one grower works for another and is perhaps higher than would be the actual cost of keeping a team. However, in the case of the fruit ranchers so many of the farms are specialized that profitable employment for these teams throughout the season can not be depended on, as on the large diversified farms. Thus \$0.15 per hour, although apparently a rate comparatively higher than the man-hour rate, is really a fair rate, all things being considered. It is necessary to keep horses on these ranches. Man labor is at all times present in the community, and its rate is determined by the community, while the rate of the horse labor is determined by the size and type of farm on which the orchards are located.

SOCIAL CONDITIONS.

The social conditions are all that could be desired. There are excellent schools and churches within easy access of most parts of the valley, and farmers' social organizations flourish. The type of farm is generally extensive enough so that the children remain in the community and help build it up. The farmers as a class come very largely from the same walk of life and thus are able to understand and cooperate with each other more or less on a common basis.

Such modern rural improvements as mail service, telephones, etc., are found throughout the region.

TRANSPORTATION.

This district is somewhat at a disadvantage in being a long way from the centers of distribution. This disadvantage is most marked in the case of the fruit industry, for fruit, especially soft fruit, is a highly perishable product.

The Payette Valley Railway traverses the Payette Valley and connects with the Oregon Short Line Railway. The town of Payette is located on the main line of the Oregon Short Line. The shipping facilities from here are good, but some idea of the distance from the

nearer large cities may be obtained from the fact that Payette is 462 miles from Salt Lake City, Utah, and 460 miles from Spokane, Wash.

In early years much of the fruit was disposed of in the local markets, especially in the mining towns and the small cities of Idaho. However, with the increased production in other parts of the State it was necessary to find an outlet into the large trade channels of the country.

SOIL.

The soils in the parts of Payette Valley where fruit is grown are of various types. The prevailing type is a sandy loam varying greatly in texture and depth in different parts of the valley. Most of the soil along the Payette River is of an alluvial nature. The river bank is comparatively low, but the lands are not generally subject to overflow. The sandy-loam type of soil, found on the bench and higher cultivated lands on which much of the best fruit is located, varies from 2 to 4 feet in depth, and the subsoil is permeable to water. Crops of all kinds apparently do well on this type of soil. There are some types found in which the surface soil is the sandy loam, a few inches in depth, shading into the clay loam at a depth of about 2 feet. Much of this loam area is underlain with hardpan.

The sandy-loam type of soil found about Fruitland seems especially adapted to fruit culture. Much of this region is believed to have been formerly a large fresh-water lake, the soil being composed in many places of very thick sedimentary deposits. This region also is formed largely of volcanic material. Much of the soil contains a considerable percentage of soluble salts, and alkali often appears on the surface after irrigation.

CLIMATE.

The climate of the Payette and Snake River Valleys is arid to semiarid. It is characterized by little precipitation, a relatively low humidity, moderate temperature, abundance of sunshine, clear air, and slow wind movement. The annual precipitation is much greater in the mountains than upon the lower lands. This region is dependent upon the mountain snows formed during the winter for its supply of water for irrigation during the summer. Low water or a lack of water for sufficient irrigation is due to a relatively light snowfall the preceding winter. The mean annual temperature for Payette is about 50° F. The maximum temperature during the past 15 years was 111° F. on July 23, 1905, and the minimum for the same period was -26° F. on January 26, 1910. Table I shows these temperatures, together with the dates of the last killing frost in the spring and the first in the autumn. Late frosts are not uncommon throughout this region, and they often cause considerable damage and render the fruit crop uncertain. Hailstorms also sometimes occur. However, the damage from hail is usually much less than in fruit regions at higher altitudes.

¹ Soil survey of the Boise area, Idaho (Field Operations, Bureau of Soils, 1901).

TABLE I.—*Dates of spring and fall frosts, annual rainfall, and mean annual temperature at Payette, Idaho.*

[Altitude, 2,159 feet.]

Year.	Last frost in spring.	First frost in fall.	Annual precipitation.	Annual temperature.	Highest temperature.		Lowest temperature.	
					Degrees.	Date.	Degrees.	Date.
1900.....	Apr. 13	Sept. 25	10.60	53.7	104	July 30	10	Dec. 31
1901.....	June 4	Oct. 16	13.50	53.3	106	July 23	5	Feb. 8
1902.....	May 1	Sept. 16	14.04	51.2	102	June 23	-13	Jan. 28
1903 ^a								
1904.....	June 23	Oct. 16	18	52.1	107	Aug. 13	-3	Jan. 4
1905.....	May 21	Oct. 8	8.86	51.2	111	July 23	-2	Feb. 11
1906 ^a								
1907.....	May 2	Sept. 14	9.95	51.3	103	Aug. 1	-1	Jan. 16
1908.....	Apr. 29	Sept. 26	7.52	50.7	108	July 31	5	Feb. 1
1909.....	May 17	Sept. 18	10	50.6	104	July 22	-2	Dec. 28
1910.....	Apr. 6	Sept. 29	10.38	50.1	107	July 13	-26	Jan. 3
1911.....	Apr. 16	Sept. 26	9.74	48.9	104	July 17	-3	Dec. 21
1912.....	May 18	Sept. 16	13.15	48.4	101	do.....	-23	Jan. 8
1913.....	May 17	Sept. 18	14.26	48.9	102	Aug. 24	-7	Jan. 6
1914.....	June 5	Oct. 24	5.90	50.3	103	Aug. 14	-8	Dec. 8
1915.....	May 4	Sept. 14	9.67	50.9	103	July 22	-5	Dec. 30
Average (14 years)...	May 10	Sept. 28	11.11	50.8	104.6	July 29	-5.2	Jan. 10

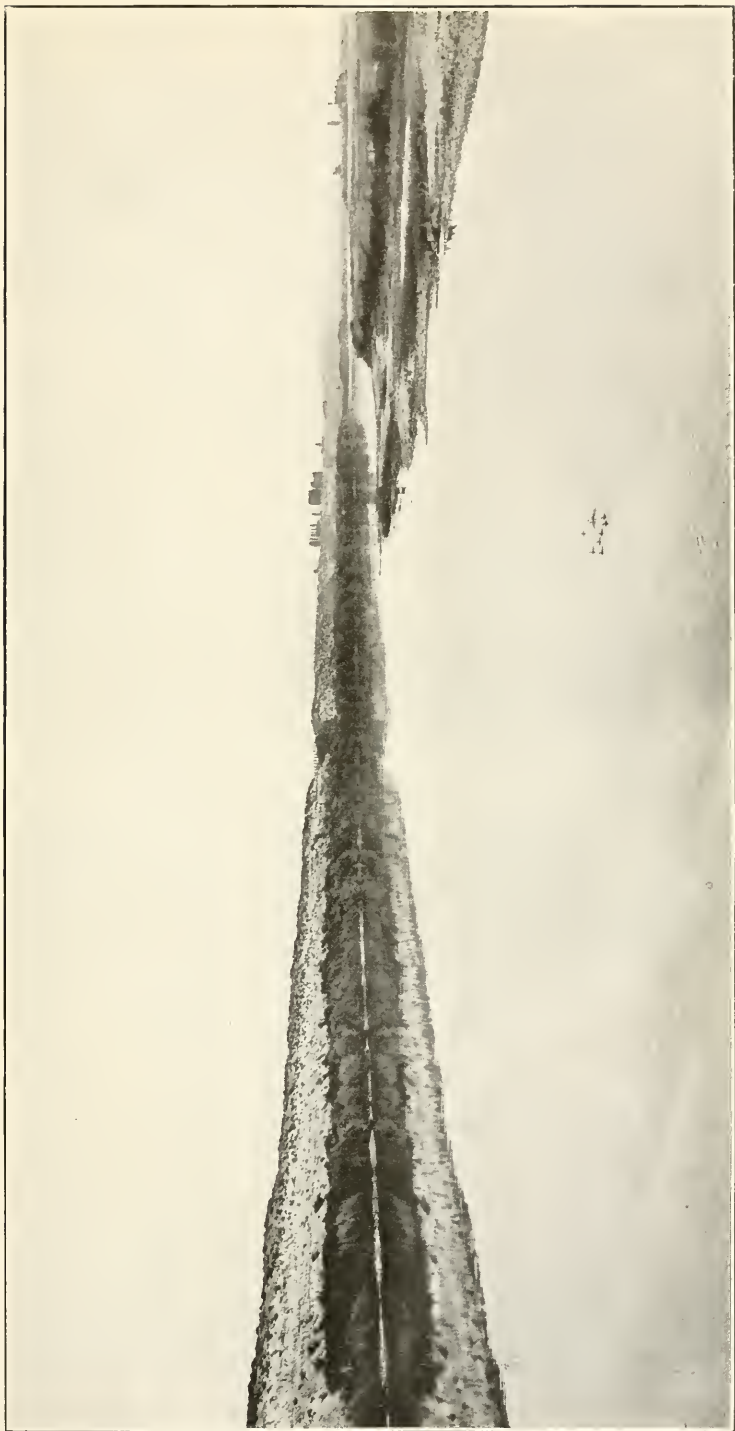
^a Data incomplete.**FARM ORGANIZATION.**

The Payette Valley is a comparatively old and established farming section. It is one of general farming, although fruit occupies an

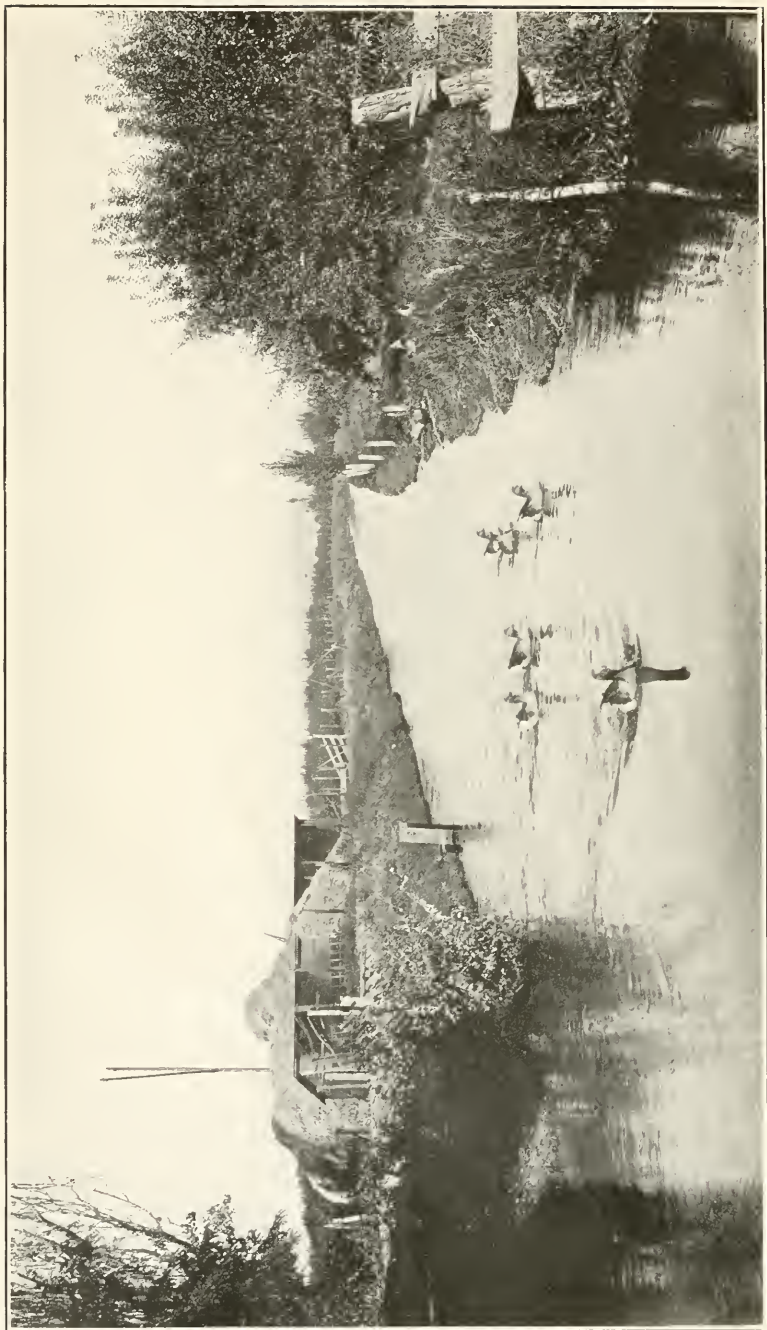


FIG. 4.—A large alfalfa field near Payette at the time of harvesting the third crop. Alfalfa often yields 8 tons per acre in this region.

important place in its agriculture. (See fig. 3.) The fruit areas are limited and for the most part are located near a few shipping stations. The average size of the farms included in this investigation



THE SNAKE RIVER NEAR PAYETTE, SHOWING THE BENCH-LAND FORMATION AND BROAD STRETCHES OF BOTH ARID AND IRRIGATED LAND.



AN IRRIGATION DITCH IN THE PAYETTE REGION.

Note the orchards bordering on either side.

is 53.39 acres, with 11.33 acres in bearing apples. This is a much higher percentage of orchard land than would be found by taking all the farms in the valley. The farms about Fruitland are very largely specialized fruit farms, and in many cases the acreage is made up wholly of fruit. In the somewhat outlying districts, which were settled more recently and irrigated, the type of agriculture is much more general.

The community as a whole may be considered a staple farming community, as there are enough of various farming enterprises to insure the success of at least a portion of the ranchers each year. Dairy farms, of which there are a number in this region, are organ-



FIG. 5.—A farmstead scene on one of the higher bench lands. Owing to difficulty in irrigating and the high cost of water, some of these settlers have had to economize in order to retain their land.

ized on the basis of raising all the feed to be used on the place. On most of the dairy farms considerable hay and grain are sold. (See fig. 4.) Nearly all the fruit growers keep at least some stock, those with mulch-crop orchards keeping the greater number. Nearly every rancher raises hogs for home use and several for sale. The growers also raise garden truck, potatoes, etc., for home use, so that the farm contributes a very large percentage of the products used by the occupants.

Tributary to this region are large stock-grazing areas. Much of the land recently irrigated is devoted to raising alfalfa. (See fig. 5.) Raising clover and alfalfa seed is also an important and profitable branch of farming found here. As might be expected, the more intensive type of farming is found near the towns, where the fruit

is handled by local warehouses and associations without necessitating any long haul.

In speaking of Payette Valley and Canyon County area as a region it may be considered as representing a very successful and diversified type of agriculture. However, the farms studied are all fruit ranches, for the most part somewhat specialized. The orchards on those which are not specialized show more or less a lack of care. Especially is this true of the large ranches where cattle are kept.

The men found on these ranches are for the most part farmers; that is to say, they are not men from other professions who have selected farming and apple growing as a means of retiring from active life, as have so many residents of other fruit sections of the Northwest. These men did not expect unusual prices or crops, and with land at a reasonable figure they have been able to build up a stable business. There are of course some ranchers who located on sections hard to irrigate, and who, caught in years of low prices with little working capital, have lost out.

In general, the ranchers are intelligent and progressive and willing to adopt new ideas and to apply them to conditions. They are practical men of limited capital who tend to develop their farming along more conservative lines than one finds in certain regions where speculators have been responsible for the development.

FARM INVESTMENTS.

The average total investment per farm in the case of the 38 ranches for which data were obtained is \$20,689.62, the average size of farm is 53.39 acres, and the investment per acre of apple orchard averages \$613.16.¹

Table II shows the comparative investments on the clean-cultural and mulch-crop orchards. The machinery equipment investment on the farms studied (\$542.63 per farm) represents present value of equipment. It may be stated, however, that the equipment on these farms is generally in fairly good condition, much of it being comparatively new.

As might be expected, the mulch-crop orchards show the greatest investment in stock other than horses. Hogs often are pastured on the alfalfa orchards.

¹In all these investment figures each farm is given the same weight on an acre basis.

TABLE II.—*Size of farms and of investments for farms studied in the Payette region, Idaho.*

Item.	System of orchard management on farm.		All records.
	Clean-cultural.	Mulch-crop.	
Number of records.....	16	22	38
Average size farm (acres).....	60.05	48.55	53.39
Investment per farm:			
Total.....	\$22,324.28	\$19,500.77	\$20,689.62
In land and improvements.....	\$20,697.66	\$17,818.18	\$19,030.59
In equipment.....	\$531.25	\$550.91	\$512.63
Average size orchard (acres).....	13.56	9.70	11.33
Per cent of farm in orchard.....	33.65	37.88	36.10
Investment per acre of orchard:			
Total.....	\$581.25	\$636.36	\$613.16
In equipment.....	\$16.91	\$23.09	\$20.50
Per cent of total farm investment apple orchard represents.....	38.27	36.34	37.16
Per cent of land and improvement investment apple orchard represents.....	41.59	39.80	40.55
Number of horses per farm.....	4.19	3.50	3.79
Investment in other stock per farm.....	\$496.00	\$666.41	\$594.66

The investment in farm land on the farms studied in the Payette region determines to a great degree the success of the farmer. In the earlier years settlers bought or homesteaded land and developed it gradually, thus acquiring the land at a much lower price than did the later settlers, who usually bought from real estate companies and paid much of their capital down on the land. For this reason many of these men who came from other parts and paid \$300 to \$500 and often more per acre for some of this land found themselves unable to compete with those who had acquired land at a much lower figure. Thus, in years of bad fruit prices and general poor crops men with little means of marketing their produce without an actual loss have not been able to succeed. Others are having trouble in meeting the interest payments on the heavy mortgages which they carry.

ORCHARDS.

SIZE AND TYPE.

The apple orchards in the valley differ greatly in size, but those studied average 11.33 acres. The 16 clean-cultural orchards average 13.56 acres, and the 22 mulch crop, 9.70 acres. These orchards vary in their general condition and in the number of trees per acre. Many of them are more or less neglected, and some are on soil not well adapted to fruit culture. Others are located in regions liable to frost.

The poorest orchards are those in alfalfa and bluegrass which have been down for a number of years and have been cut off or pastured annually by stock and never returned to the land. There is a tendency to neglect the older orchards, especially as regards soil management.

AGE OF ORCHARD.

The orchards in the Fruitland and Woodspur districts near Payette average nearly 15 years in age. There were many early plantings, but these were confined to very limited areas. Some of the older orchards are found in the vicinity of New Plymouth, but they are scattered widely. Many of the older orchards are neglected.

INVESTMENT IN ORCHARDS.

The average investment per acre in the orchards of the Payette district is much less than that of some other fruit regions. (See Table II.) This is due to the fact that Payette Valley is not as favorably located as some other regions in regard to transportation and is in a general farming region which has been developed along non-speculative lines.



FIG. 6.—A 5-year-old Delicious orchard near Boise. Note the habit of growth and size of these trees. This grower believes in little pruning for young trees of this sort.

The average investment in bearing apple orchards is \$613.16 per acre, and the average equipment investment is \$20.50 per acre. This includes only machinery and orchard equipment. The bearing apple orchard represents 37.16 per cent of the total farm investment and 40.55 per cent of the total land and improvement investment. There is a comparatively small acreage of young apples not yet in bearing on these 38 farms, and few apples are now being planted. There is, however, a large acreage in other fruits, especially prunes.

VARIETIES.

Many varieties of apples are grown commercially in the Payette Valley, but the leading of these is the Jonathan, which usually brings a good price but has the disadvantage of being susceptible to blight and mildew. This is followed by the Winesap. Others of commercial importance are the Rome Beauty, Ben Davis, and Arkansas Black. Varieties that formerly were planted very

extensively and that are now found largely in the older orchards are Baldwin, Wealthy, Wolf River, Lawver, Arkansas, Missouri, York Imperial, and many fall varieties. There are a few varieties which are found in smaller numbers but which are popular commercially. Among these are White Pearmain, Delicious, and Stayman Winesap. The Ben Davis, although found in many orchards throughout the valley, is no longer being planted and is seldom found in orchards under 10 years of age. (See fig. 6.)

METHOD OF SETTING.

The trees are set by various methods. Usually either the square or diagonal method is used. A popular distance is 28 by 28 feet on the diagonal, but the older orchards are set by all methods, and the trees are all distances apart. The trees per acre vary between the limits of 50 and 90, the average for the farms studied being 63.

YIELDS.

The yields of the orchards studied in Payette Valley are fairly uniform. In arriving at these results the yield was secured for a period of five years, including seasons of both light and heavy yields, thus giving a fair average. It was found that in the case of the clean-cultural orchards there is a yield of 336 packed boxes per acre and in the mulch-crop orchards a yield of 338 per acre, making 5.7 boxes per tree in the clean and 5.1 boxes in the mulch crop, there being about eight more trees per acre in the mulch-crop orchards. (See Table III.)

Many factors influence the yield—the number of trees per acre, the variety, size, and age of trees, size of orchard, the amount of pruning, thinning, and propping practiced, the percentage of marketable fruit, etc. Generally speaking, the smaller the orchard the larger the yield per acre. On account of the relatively small number of orchards which were available in this region, no definite conclusions can be reached in this regard.

TABLE III.—*Packed-box yields on farms studied in Payette Valley, Idaho.*

Orchard management.	Number of orchards.	Size of orchard.	Age of orchard.	Trees per acre.	Yield per acre.	Yield per tree.
		<i>Acres.</i>	<i>Years.</i>		<i>Packed boxes.</i>	<i>Packed boxes.</i>
Clean-cultural.....	16	13.56	14.25	58.6	336	5.7
Mulch-crop	22	9.70	15.18	66.8	338	5.1
All orchards.....	38	11.33	14.79	63.3	337	5.3

The age of the orchard has little apparent effect on the yield after the trees reach 10 years of age. The Jonathan variety comes into bearing at a comparatively early age, as does also the Winesap.

In addition to the packed-box yield of 337 boxes for all orchards studied, there is also a considerable yield of culled fruit, which is not considered in the discussion of yields, though credited to the orchard.

MARKETS AND PRICES.

The apples of the Payette Valley and the immediate region have of late years returned the grower varying prices per box f. o. b. shipping station. The average price received by these 38 growers was \$1.06 per packed box in 1910, \$0.95 in 1911, \$0.62 in 1912, \$1.02 in 1913, and \$0.37 in 1914, or an average for the five years of \$0.804. The average annual cost of production per box, considering the average yield over these five years, is \$0.7111. In cases of low prices there is generally a higher yield, and consequently the cost of production is reduced somewhat for that year. However, in 1912 and 1914 the cost of production was greater than the price received for fruit. These figures refer to the price for packed fruit received by the grower f. o. b. shipping point. Only on general farms and in the case of men with considerable working capital, can growers weather years with such disastrous fruit prices as those of the year 1914.

The fruit in this region is marketed in three grades—extra fancy, fancy, and C grade—as is done in some other regions of the Northwest. The growers have had many difficult marketing problems to face, in common with other Northwest regions.

ORCHARD MANAGEMENT.

MANURING.

Manuring is practiced by 63 per cent, or 24 out of the 38 growers. In the case of the Jonathan orchards some growers do not apply manure, for the stated reason that it stimulates wood growth. The prevalence of fire blight and its activity in rapidly growing trees account for their caution in this regard.

Manure usually is applied from a wagon, one man and two horses forming the crew. Application is made generally during the spring or fall or, in some cases, as the manure accumulates. The rate of application is variable, ranging from 5 to 15 tons per acre. Table IV will serve to show the manuring practices and costs.

TABLE IV.—*Relation between manuring practices and costs of apple production on farms studied in Payette Valley, Idaho.*

Orchard management.	Number of farms.	Per acre.						Total cost per box.
		Man hours.	Horse hours.	Cost of labor.	Tons of manure.	Material cost.	Total cost.	
Clean-cultural.....	11	5.19	9.90	\$2.52	5.99	\$8.98	\$11.50	\$0.0342
Mulch-crop.....	13	6.67	13.04	3.29	6.68	10.02	13.31	.0394
All records.....	24	5.96	11.60	2.94	6.36	9.54	12.48	.0370
All records, pro rata <i>a</i>	38	3.78	7.32	1.85	4.02	6.03	7.88	.0234

a In this line appear the averages derived by distributing the cost of manuring over all the farms surveyed in order to secure a figure that legitimately can be used in figuring the regional cost of apple production.

It is found that more manure is applied annually per acre on orchards in mulch crop than on clean-cultural orchards. This is partly due to the fact that the mulch-crop orchards are smaller, thus making more manure available per acre, and partly to the fact that the farms which have orchards in mulch crop keep about one-third more stock than those which have the clean-cultural orchards. It is found that the labor cost for manuring is 1.79 per cent of the total net labor cost, while the material cost is 4.43 per cent of the total material and fixed cost, making the total cost of manuring 3.28 per cent of the annual net cost of production.

PRUNING.

Pruning is practiced generally every year by all growers. The open-head tree system is the most popular form of pruning, and from four to seven leaders with a well-opened head is the type sought. As



FIG. 7.—A young orchard near Payette from which alfalfa has been harvested. Note the flock of 700 turkeys. A great diversity of live stock is profitably raised in this section.

the principal variety of the Payette Valley is the Jonathan, it is necessary to give the tree plenty of light in order to give color to the fruit. There is no noticeable tendency as yet to head back the tops of the trees in order to keep their height reduced. (See fig. 7.) The cost of pruning is \$0.15 per tree, or \$0.0281 per box. This, as will be seen (Table V), is identical with the cost of thinning for all the orchards.

The pruning cost is somewhat higher for mulch-crop orchards than for clean-cultivated orchards. This, no doubt, is partly due to the fact that the average acreage of the mulch-crop orchards is about 4 acres less than that of those under the clean-cultural system, thus offering opportunity for more detailed care per acre. Pruning costs make up 9.16 per cent of the total net labor costs and 3.95 per cent of the total annual net cost of production.

HAULING BRUSH.

The growers in this region usually make a practice of trimming out the brush after it is pruned from the trees and saving the larger limbs for fuel. As there is a scarcity of native timber in this region, firewood is valuable, being priced at \$4 to \$5 per cord. The smaller brush is thrown on a sled or wagon and hauled to a convenient place for burning.

Considering all records, there is found to be a credit of \$0.58 per acre annually for wood and a charge of \$3.45 per acre, or \$0.0103 per box, for the hauling and disposal of brush. This makes up 3.36 per cent of the net labor cost, or 1.45 per cent of the total annual net cost of production. Where only one or two cords are obtained from the orchard each year, the labor of trimming out the heavy wood for fuel represents almost the value of the wood.

THINNING.

Thinning is practiced generally throughout the valley. The work usually is done by day labor at the rate of \$2 per day. As in other regions, thinning is practiced either by pulling the apples from the trees or by using thinning shears. The growers have many ideas as to the value of thinning. Some claim that excessive thinning of Jonathans tends to increase the apples in size and consequently to increase the liability of breaking down in storage. It is thought by many that the average-sized apple has somewhat better keeping qualities than the very large one. No definite statement can be made in regard to this question from the data at hand.

In the Payette Valley pruning and thinning are done to such an extent that the necessity for propping is obviated largely. Thinning usually is done during the early part of the season, preferably in June. There is found to be an average for those who thin of 48.64 man-hours per acre, or a cost of \$0.154 per tree; but when this is distributed among all records there are 47.36 man-hours, or \$9.47 annual labor charge per acre. This is a cost of \$0.15 per tree, \$0.0281 per box, or 9.16 per cent of the total net labor cost. The cost for thinning in the valley when prorated among all records is identical with the cost of pruning. (See Table V.)

TABLE V.—Average time and cost of pruning, thinning, and propping for farms studied in Payette Valley, Idaho.

Operation.	Per cent of growers practicing.	Man-hours.	Horse-hours.	Cost.		
				Per acre.	Per tree.	Per box.
Pruning.....	100.00	47.41	.....	\$9.48	\$0.150	\$0.0281
Thinning.....	97.37	48.64	.....	9.73	.154	.0289
Propping.....	78.95	7.60	10.32	3.07	.048	.0091

TABLE VI.—*Pruning, thinning, and propping costs when prorated over all orchards studied in Payette Valley, Idaho.*

Operation.	Per cent of growers practicing.	Man-hours.	Horse-hours.	Cost.		
				Per acre.	Per tree.	Per box.
Pruning.....	100.00	47.41	.....	\$9.48	\$0.150	\$0.0281
Thinning.....	97.37	47.36	.....	9.47	.150	.0281
Propping.....	78.95	6.00	8.15	2.42	.038	.0072

PROPPING.

Propping is not practiced so generally in the Payette region as in many other apple regions. It is found that practically 79 per cent of the growers prop. Where propping is not practiced at all it is the general rule for the growers to lighten the limbs by careful thinning and thus avoid the breaking down of the trees laden with fruit. Most growers haul out and set up props in a single operation, a wagon or truck being drawn by two horses, with one or two men to complete the crew. The cost of tending the props after being set up is very little. Board props are used almost exclusively, although a few growers use poles. These board props are usually 1 inch in thickness and vary in width from 2½ inches to 4 inches. These props usually can be bought for about \$16 per thousand board feet. The length varies from 8 to 14 feet, and the boards usually are notched or cleated at the top. The propping cost (\$3.07 per acre) is not quite one-third of the pruning or thinning cost and is 2.35 per cent of the total net labor cost, or practically 1 per cent of the total annual net cost of production. (See Table V.)

SOIL MANAGEMENT.

There are two distinct types of soil management in the valley, the clean cultural and the mulch crop. The mulch-crop system of management as practiced in the valley is largely one of keeping the orchard in sod for a period of years, so that, properly speaking, it receives very little benefit from a leguminous mulch crop. Some of these orchards are in bluegrass, but all are classed as mulch-crop orchards, as they are under the same general system of management. Sixteen of the 38 orchards are under the clean-cultural and 22 under the mulch-crop system. The average annual cost of plowing and cultivating on the former is \$9.37 per acre, while in the case of the latter it is \$2.72.

The system of soil management practiced is the most important factor influencing the health of the tree and the general producing capacity of the orchard.

The soil in the orchards of the valley apparently has not yet been depleted by clean cultivation, as has the soil of certain other regions. The growers seem to realize that humus is necessary for the soil and have applied considerable manure, thus lessening the necessity of returning humus to the soil in other ways. If this mulch cropping were practiced with a view to aiding the orchard and handled accordingly, the results no doubt would be different, but many of the larger and older orchards are down in mulch crop which has been there many years and is practically sod.

A few orchardists turn under their mulch crops from time to time, and one of the most successful orchardists in the valley alternates the mulch-crop and clean-cultural system every year. To a great extent the grower himself can determine from the health and vigor of his own orchard which type of soil management he should follow, and a combination of both systems would seem to be best as far as the orchard itself is concerned, but perhaps not the most profitable when the pasture and hay value of the crop on the orchard is taken into consideration.

CULTIVATION.

All the orchards in the valley have at least a small annual charge for cultivation. The least charge appears on those orchards which are in bluegrass for permanent pasture, in which case only occasional rills for irrigating are made, or sometimes the orchard may be disked, or harrowed with the spring tooth. (See Table VII.)

In regard to plowing, it was found that 12 (nearly 32 per cent) practice it, plowing on an average of 1.38 acres a day. The cost is \$3.61 per acre for those who plow. (See Table VII.) Considering all orchards under both kinds of management, the acre charge for plowing is \$0.85, and the box cost \$0.0025.

Twenty-two (nearly 58 per cent) of the orchardists disk, the 7-foot riding disk being used ordinarily. This disking is done usually in the early spring and often prior to any other operation on the soil. A comparatively small percentage of the growers use the spring-tooth harrow. The spike-tooth harrow is used by 15 (nearly 40 per cent) of the orchardists. Various other implements are used on a few orchards.

Cultivation begins as a rule during the latter part of March or shortly after. Plowing is often the first operation in the spring. Some growers use either spring or spike tooth harrow for the first operation and follow this with a disk in order to loosen up the soil. Later in the spring, after the weeds have started, the disk may be used again, either one or both ways, and then followed by the spike or spring tooth harrow before the first irrigation. Other growers may in addition use the cultivator once or twice.

TABLE VII.—*Cultivation practices on the 38 farms studied in Payette Valley, Idaho.*

Implement.	Per cent of number using.	Number clean.	Number mulch crop.	Man-hours.	Horse-hours.	Acres per day.	Cost per acre.	Width of implement.
								<i>Feet.</i>
Plow.....	31.58	8	4	7.23	14.46	1.38	\$3.61	1
Disk.....	57.89	12	10	1.77	3.54	5.65	.89	7
Spring-tooth harrow.....	15.79	4	2	1.81	3.62	5.52	.91	7
Spike-tooth harrow.....	39.47	11	4	.96	1.92	10.42	.48	9
Crease shovel plow.....	36.84	7	7	1.64	3.28	6.10	.82	.....
Crease (6-foot cultivator).....	10.52	3	1	.92	1.84	10.87	.46	.....
Float.....	10.52	4	.....	1.24	2.48	8.06	.62	8 by 14
Weeder.....	5.26	1	1	.96	1.92	10.42	.48	8
Cultivator.....	5.26	2	.....	1.00	2.00	10.00	.50	8
Corrugator.....	5.26	.....	2	1.50	3.00	6.67	.75	.....
Alfalfa ditcher.....	2.63	.....	1	1.88	3.76	5.32	.94	.....
Mormon ditcher.....	2.63	.....	1	2.00	4.00	5.00	1.00	.....
Roller.....	21.05	4	4	1.01	2.02	9.90	.51	.....

It can not be said that the average grower practices intensive cultivation as it is practiced in some commercial districts. The water supply has been adequate to supplement the normal rainfall, so that there has been no pressing need of conserving moisture. Some growers cultivate their orchards between irrigations, particularly after the first. Most orchardists, however, do not cultivate the land after the first irrigation rills have been laid out. For all orchards under all systems of management the average total annual cost for cultivation, including plowing, is \$5.52 per acre, or \$0.0164 per box. (See Table VIII.)

TABLE VIII.—*Total of all cultivation costs per acre and per box on farms studied in Payette Valley, Idaho.*

	Clean cultural.		Mulch crop.		All orchards.	
	Cost per acre.	Cost per box.	Cost per acre.	Cost per box.	Cost per acre.	Cost per box.
Plowing.....	\$1.44	\$0.0043	\$0.42	\$0.0013	\$0.85	\$0.0025
Other cultivation.....	7.93	.0236	2.30	.0068	4.67	.0139
All cultivation.....	9.37	.0279	2.72	.0081	5.52	.0164

MULCH CROPS.

The use of mulch crops has become general within the last few years. Only a few orchardists take off more than one crop of hay, and many use the crop entirely for pasture or leave it on the ground, although many others make three cuttings, which may be taken off or left on the ground as a mulch. The most common method of handling mulch crops in this region, however, is to allow hogs to pasture off the crop. In this way the soil is enriched and at the same time the wormy and inferior fruit on the ground is utilized for feed.

Where mulch crops are grown, it is the practice to go on the land with a disk in the latter part of March or the first of April. The

orchardists may follow this with some other cultivation tool, such as the spring or spike tooth harrow. Following this, however, there is no further treatment of the soil aside from the rilling for irrigation. A few men plow under their mulch crops as an annual practice, but most of them leave them in for several years, although the growers say it is the intention to turn under and resow the mulch crop at intervals of from three to four years.

The kinds of mulch crops used vary somewhat from those in other regions. Alfalfa seems to be the most popular and is used largely for pasture. There are many orchards in bluegrass, which also is

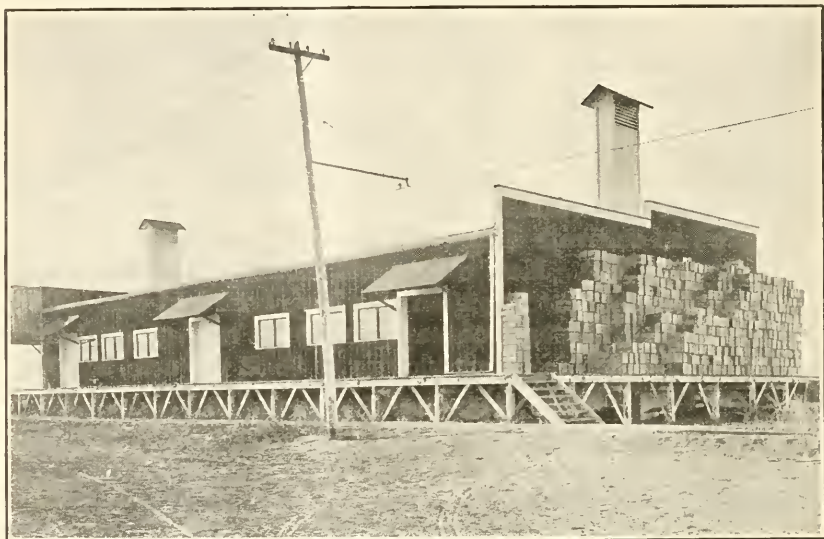


FIG. 8.—A large packing shed of a fruit grower near Boise.

used as a pasture. This has been down in some cases 10 or 12 years. The older orchards, which show the greatest amount of neglect, are the ones which are in mulch crops, or, more properly speaking, which have been in sod for a number of years. Such an orchard really can not be said to be under the mulch-crop system.

These mulch-crop orchards are often irrigated by means of flooding, although about half are irrigated by means of rills. Generally the pastured orchards are flooded, while the better-cared-for orchards are rilled.

It is found that 7 of the 22 men who use some form of mulch crop have their orchards in clover, and 9 have them in alfalfa. Four pasture their orchards in addition to taking the hay off, while seven make a practice of pasturing the orchard and not taking off any hay. There is a net credit of \$7.40 per acre for hay and pasture, or a credit per box of \$0.022, for the 22 growers who use some kind of mulch crop. (See Table IX.)

TABLE IX.—*Credit derived from mulch crop on farms studied in Payette Valley, Idaho.*

Number of records.	Per acre.					Net credit per box.
	Cost of harvesting.	Hay credit.	Pasture credit.	Total credit.	Net credit.	
22.....	\$1. 87	\$0. 21	\$3. 06	\$9. 27	\$7. 40	\$0. 022

IRRIGATION.

In the Fruitland district there are two important irrigation projects. One is the Noble ditch, watering about 6,000 acres, with an average maintenance fee of but little over \$1 per acre per year. This was organized in 1894 and receives its water from the Payette River. The higher land in the south Payette district is watered by the Farmers' Cooperative ditch, which is a large project embracing about 13,000 acres. It taps the Payette River at Emmett, farther up the stream than the opening of the Noble ditch. The maintenance charges for this ditch are from \$1.50 to \$2 per acre per year; the water from it is turned on about the first of May.

In the region north of Payette, or the Woodspur section, are found districts known, respectively, as the Lower Payette district and Payette Heights. The former comprises the greater acreage. The Payette ditch furnishes water at a low maintenance cost which will average about \$0.50 per acre per year. In order to water the Payette Heights, it has been necessary in many cases to install pumping plants to lift the water up to the higher lands. This makes the cost of irrigating very much higher than that on lands watered by a gravity flow. In many cases it is \$6 to \$7 per acre per year for the water delivered on the land. For the most part the water is conducted in open ditches or flumes, and piping systems are not common. It is necessary to irrigate all orchards in this region, as the annual rainfall is not sufficient to sustain the trees. On an average 4.7 irrigations are made annually on the 38 orchards studied in the valley, the mulch-crop orchardists averaging 5.18 irrigations, while the clean cultural average 4.06. In the case of the clean-cultivated orchards, the first irrigation usually is made during the latter part of May or the first of June, and the last during the latter part of August. These irrigations are made at regular intervals during this period. (See Table X.)

TABLE X.—*Average number of irrigations and practices for farms studied in Payette Valley, Idaho.*

	Number of irrigations.	Average man hours per irrigation.	Total man hours for all irrigations.	Cost per acre per irrigation.	Cost per acre for all irrigations.	Cost per box for all irrigations.
Clean cultural.....	4. 06	2. 434	9. 88	\$0. 486	\$1. 98	\$0. 0059
Mulch crop.....	5. 18	1. 725	8. 94	. 345	1. 79	. 0053
All records.....	4. 71	1. 983	9. 34	. 398	1. 87	. 0055

The rilling for the irrigation is done either by shovel cultivators, single plows, corrugators, or homemade rillers. In irrigating the mulch-crop orchards the system of flooding is used to a great extent. In flooding the time is considerably reduced, for this method aims to cover the whole orchard by allowing the water to follow its own course. The topography of the land and type of soil will determine the method of applying the water.

Where mulch-crop orchards are rilled, a common tool used is a "corrugator," consisting of two metal shovellike attachments with a substantial iron frame. Six rills usually are made per tree row. As a rule, the date for the first irrigation is earlier on mulch crop than on the clean-cultivated orchards, the first watering usually being made during the first two weeks in May and seldom later than the last of this month. In a few cases men flood their orchards in the fall.

The average time for irrigating the mulch-crop orchards is 1.72 man-hours, with an acre cost of \$0.345, or for the 5.18 irrigations there is a charge of 8.94 man-hours and a cost of \$1.79 per acre, or \$0.0053 per box for labor.

Considering all records, irrigation costs \$1.87 per acre or \$0.0055 per box. The average annual water tax is \$1.28 per acre, or \$0.0038 per box, and the total for labor and water tax is \$3.15 per acre, or \$0.0093 per box.

SPRAYING.

The spraying program of the Payette district is comparatively uniform. All growers from whom records were taken make one dormant lime-sulphur spray and one calyx arsenate-of-lead spray. They average 2.09 other arsenate-of-lead sprays, making an average of 4.09 sprays for the season.

All the growers except three own their own spray rigs, which generally are of standard make, although there are a few assembled rigs. When the spray outfit is hired, the usual price is \$1 per hour for man, team, and outfit. The grower's average investment in the spray outfit for those owning them is \$360. The spray-rig engine varies from 2 to 3½ horsepower, the majority being 2½. The 200-gallon tank is the one most commonly used. There are very few men who use spray towers on their rigs, though in the older orchards spray towers are an advantage.

It is found that the life of the average spray rig is approximately 9½ years, and that the depreciation amounts to \$37.80 annually. This, added to an annual upkeep of \$16 and an annual interest charge of \$28.80 on the original investment, makes an annual charge of \$82.60 per spray rig.

Approximately 20 acres of fruit are sprayed annually by each spray rig. This would then give an acre charge of \$4.13 for depreciation,

upkeep, and interest, together with \$0.74 for oil and gasoline, making a total annual charge of \$4.87 per acre for the use of the spray rig and engine. Those who hire their spraying done pay for the rig itself about \$0.50 per hour, wages of man and team making up the remainder of the charge of \$1 per hour. Allowing the same number of spray hours per acre for those who hire the spraying done, there would then be an annual charge of \$5.73. In reality, however, there are usually fewer hours spent per acre for those who hire than for those who do their own spraying. There is an average of 10 spray-rig hours an acre for those who hire the spraying done, thus making the annual cost \$5 per acre, or \$0.13 more per acre than for those who own their spray rig.

Most spray rigs have two leads of 50-foot rubber hose and use an 8 to 10 foot spray rod. The pressure varies from 125 to 275 pounds, but usually is about 200 pounds.

There are many orchard pests and diseases which the grower finds it necessary to control. The most important pests are the San Jose scale and the codling moth. These made their appearance in the early years of the commercial apple industry in this region. There are others which require less attention and which the growers in this section have had little trouble in combating as yet, such as the green aphid, woolly aphid, oyster-shell bark louse, blister mite, etc.

TABLE XI.—*Payette spraying practices and costs (38 records).*

Kind of spray.	Average number of sprays.	Per acre.			Gallons per acre.	Gallons per tree.	Per acre.			Total cost per box.	Strength of spray.
		Man-hours.	Horse-hours.	Acres per 10 hours.			Labor cost.	Material cost.	Total cost.		
Lime - sulphur dormant spray.	1.00	8.24	6.05	3.31	388.56	6.14	\$2.56	\$7.29	\$9.85	\$0.0292	1 to 9.
Calyx or first lead arsenate spray.	1.00	7.51	5.42	3.69	378.09	5.97	2.31	2.00	4.31	.0128	2 lbs. lead to 50 gals. water.
Other lead - arsenate sprays.	2.09	15.96	11.45	3.65	776.49	12.27	4.91	4.14	9.05	.0269	2 lbs. lead to 50 gals. water.
Total all sprays.	4.09	31.71	22.92	3.57	1,543.14	24.38	9.78	13.43	23.21	.0689	

The more important apple diseases are blight, mildew, and apple scab. Blight is by far the most serious, and as yet there is no effective remedy other than cutting out the infected parts 6 or 7 inches below the infection, using great care to disinfect the tools with corrosive sublimate. Mildew and scab are present and have caused considerable trouble. The apple scab made its first appearance in Idaho in Latah County, in 1897, being noticed at a much later date in Canyon County. The growers considered in these records, however, had not made a practice of spraying to prevent either of these diseases up to the time these data were taken. It was found that all growers thoroughly

believe in the application of the first spray, made for the San Jose scale. Heavy losses have been suffered in the past from this pest, and now a great deal of attention is given to its control. When all growers spray with a dormant lime-sulphur spray of a strength varying from 1 to 8 to 1 to 11, it apparently holds the scale in check, so that little damage to the fruit is experienced. Applications of this dormant lime-sulphur spray are made every year, usually during the latter part of March or the first of April, after the buds begin to swell.

The usual spraying crew consists of three men and two horses, two men using the two leads of hose, and the third man driving the team.

The average crew will spray 3.31 acres in 10 hours, applying 388.56 gallons per acre, or 6.14 gallons per tree. The labor cost is \$2.56 per acre, and the material cost \$7.29, making a total cost of \$9.85 per acre, or \$0.0292 per box. (See Table XI.)

The first lead-arsenate spray of the season, known as the calyx spray, is made for the control of the codling moth. This application is made when about 80 per cent of the petals have fallen, which is usually the first or second week in May. It ordinarily consists of lead arsenate and water, paste lead arsenate being used at the average strength of 8 pounds to a 200-gallon tank of water, or dry lead arsenate 4 pounds to a 200-gallon tank of water. Lime-sulphur or atomic sulphur, sometimes used in this spray for scab prevention, is not as yet used by any of these growers. In applying this spray the average crew will spray 3.69 acres in 10 hours, applying 378.09 gallons per acre, or 5.97 gallons per tree, with a labor cost of \$2.31 and a material cost of \$2.00, or a total cost of \$4.31 per acre.

The second spray for the control of the codling moth usually is made about three weeks later than the first and is spoken of as the "three weeks' spray." In severe cases, however, a spray is made 10 days after the time the petals fall, using the same strength of lead as in the case of the calyx spray. The third, and usually the last, application is made during the last week of July. Where four applications are made, the second usually follows the calyx in about 10 days, the third about the first of June, and the fourth the latter part of July. As a rule, however, either the second or fourth spray is omitted, making a total of only three applications of lead for the control of the codling moth larvæ. For these lead sprays other than the calyx spray, the average crew will spray 3.65 acres per day, applying about 1,350 gallons in this time.

Considering all sprays, the total labor cost for spraying is \$9.78, while the total material cost is \$13.43, making a total of all costs for labor and material of \$23.21 per acre, or \$0.0689 per box. The cost of the spray rig itself, including the gasoline, upkeep, etc., is not included here, but is included under the annual equipment charge to be found under the fixed costs.

In 1915 and 1916 atomic sulphur was used in some other sprays, than the calyx and doubtless will be used more generally in the future for the control of apple diseases, particularly mildew.

MISCELLANEOUS.

There are some items which do not appear in the regular labor column. These are classed as miscellaneous items. The principal of these are cutting blight, cleaning laterals and waste ditches, mowing weeds, hoeing about the orchard, and doctoring trees, and there are many other small items which appear on but a few farm reports. In this district miscellaneous labor is made up entirely of man labor, the cost of which is \$1.41 per acre, or \$0.0042 per box.

HANDLING THE CROP.

The cost of handling the crop makes up 60.95 per cent of the total annual net labor cost of production, or 26.30 per cent of the total of all net costs. The items which go to make up this handling are: Picking, orchard foreman, all packing-house labor, including sorting, packing, nailing, stamping, waiting, etc., and any other labor about the packing house, such as packing foreman. The hauling, which is a part of the handling costs, includes hauling shooks from the station, hauling empty boxes to and full boxes from the orchard, and hauling packed boxes to the association or station. Before discussing these items it should be stated that a large number of men in this region pick their fruit and haul it to the association or warehouse where it is packed, the grower being charged a price which varies with different branch packing houses of the central association. At the time of this study, 14, or practically 37 per cent of the 38 growers, did not pack their own fruit, but took it to these association packing houses, where it was sorted, sized, and packed.

PICKING.

Picking in this region is done very largely by day labor at the rate of \$2 per 10-hour day, although sometimes growers contract with men to pick at \$0.04 per box. The picking season usually begins in early September and lasts until late in October. The first commercial variety picked in this region is the Jonathan. Growers ordinarily begin to pick these about September 10, or sometimes earlier where apples are intended for foreign trade. Two or more pickings often are made for such varieties as the Jonathan and Rome Beauty. These apples are picked for color, and as all the apples on the tree are not colored evenly at one time, it is desirable to make more than one picking. Other varieties usually are taken off at one picking. On this account the grower can pick more boxes per day of such varieties as Ben Davis than he can of Jonathan.

All picking is done by hand. The ordinary stepladder, varying in length but usually light and easily handled, is commonly used.

A canvas picking bag is used by nearly all growers. Some of the growers use orchard boxes, in which the apples are hauled from the orchard to the packing house. These boxes are larger and heavier than the ordinary apple box and are commonly called lug boxes. However, as in other Northwest sections, these growers usually handle their apples in the ordinary packing boxes which have been made up and hauled into the orchard at convenient places for the pickers. As these same boxes are used for packing, more care is taken in handling them than in handling the lug boxes.

It is found that the average picker will pick 67 loose boxes per day, or enough to make 44 packed boxes. The average picking crew consists of from three to four men. On the farms studied, with a yield of 337 boxes per acre, it costs \$15.53 per acre, or \$0.0461 per box for picking. (See Table XIII.) The picking time and cost are affected by yield, size of orchard, variety of apple, weather conditions, uniformity of the fruit, and many other factors. Owing to the limited number of orchards from which data were obtained, no definite conclusions could be reached as to the relative influence of these different factors on the cost.

There are a few men with large orchards who employ an orchard foreman to superintend the pickers. On the total labor cost this foreman labor is combined with the picking labor, but influences it very little, the cost, including the foreman, being \$0.0465 per box. This is because there were only two orchards which used an orchard foreman who did not also act as a picker.

The picking labor, including the orchard foreman, makes up 15.16 per cent of the total net labor cost and 6.54 per cent of the total annual net cost of production.

HAULING.

Hauling costs include hauling shooks, hauling the loose boxes to and from the orchard, and hauling to the station or association. Twenty-four men haul shooks, the others handling their fruit through an association from which they obtain their made-up boxes. In the case of these 24 orchardists, one man and team haul 471 shooks per load a distance of 1.24 miles at a cost of \$0.87 per acre, or \$0.0026 per box. (See Table XII.) After these shooks are hauled, they are made up on the ranch at an average cost of \$0.85 per hundred. This cost is included under made-up box cost in material and fixed costs. All growers haul empty boxes to the orchard. Fourteen of these haul from the association packing house, while 24 haul from their own packing house on the ranch. The cost of hauling

these loose boxes to the orchard is \$0.006 per box. There are 24 growers who haul full loose boxes into the packing house, the other 14 hauling direct to the warehouse or association. An orchard truck is generally used by the 24 who haul to their own packing houses, hauling a load of 53 boxes at a cost of \$3.96 per acre, or \$0.0121 per box.

All growers haul full boxes of fruit from the ranch to the association or station. Twenty-four of these haul packed boxes, while 14 haul boxes to be packed at the association. The average cost is \$5.16 per acre, or \$0.0153 per box.

TABLE XII.—Average cost for hauling where a crew of one man and two horses is used.

	Number practicing.	Boxes per load.	Number of miles	Cost.		
				Per acre.	Per box.	Per box per mile.
Haul shocks.....	24	471	1.24	\$0.87	\$0.0026	\$0.0021
Haul empty out.....	38	99	.....	2.01	.0060	.....
Haul full in.....	24	53	.....	3.96	.0121	.....
Haul to station.....	38	72	1.32	5.16	.0153	.0116

When all hauling costs are considered they are found to amount to \$0.0306 per box. This is relatively low, as compared to the cost in some regions, owing to the fact that most orchards here are in the immediate vicinity of the shipping stations and also to the fact that hauling the full boxes from the orchard to the rancher's packing shed is done away with in the case of the 14 orchardists who haul their loose boxes direct to the association packing house.

PACKING-HOUSE LABOR.

The principal items of packing-house labor are the sorting and packing. As 14 of these men have their apples packed by the association, this discussion applies only to the 24 growers who do their own packing. All these 24 growers have sorters for their fruit apart from the packers.

SORTING.

Sorting in this region is nearly all done by hand, women being largely employed for this work. As yet very few mechanical sizers have been brought into the valley, except for use in association packing houses. The apples are usually sorted into three grades; extra fancy, fancy, and C grade. The apples that are used for cider nearly all pass the sorters; that is to say, these apples are taken out by the sorters from the boxes of picked fruit. The labor of sorting depends on the variety of fruit and its relative freedom from insect or fungus injury. The sorters usually do not size the fruit, but only sort it into the grades, the packer sizing his own fruit.

The average sorter when doing nothing else will sort from 75 to 80 packed boxes in 10 hours, or about 125 loose boxes. The sorting cost when the 24 orchards are considered is \$8.84 per acre, or \$0.0266 per box.

TABLE XIII.—Average cost for handling other than hauling (38 records).

Item.	Number of orchards practicing.	Boxes in 10 hours.	Cost per acre.	Cost per box.	Number in crew.
Picking.....	38	43.38	\$15.53	\$0.0461	3.21
Supervision by picking foreman.....	2	289.86	2.62	.0069	1.00
Sorting.....	24	75.19	8.84	.0266	3.54
Packing.....	24	55.75	16.62	.0500	5.63
Nailing and waiting.....	7	170.94	3.35	.0117	1.00
Nailing.....	17	312.50	2.25	.0064	1.00
Waiting.....	12	259.74	2.39	.0077	1.00
Supervision by packing foreman.....	11	338.98	2.17	.0059	1.00
Other packing labor.....	9	196.08	3.58	.0102	1.22

PACKING.

The packing wage per box is ordinarily \$0.05 for sorted apples. Much of the packing is done by young women. In a few cases packers are hired by the day.

Provision for packing-house accommodations has been made by nearly every grower. (See fig. 8.) Sometimes barns or sheds are used for this purpose during the harvesting season. In a few cases complete and well-arranged packing sheds have been built at a cost of several hundred dollars. The average packing shed, however, does not represent a very great outlay of money. Often it is but a shed or barn temporarily converted to this purpose.

The packers have the apples before them sorted into the three different grades, which they size as they pack. The experienced packer can tell very readily by looking at the apple to what size it belongs. Thus the average packer has three or four boxes before him in which to put apples of the same grade but different sizes. The packer is usually required only to wrap and pack the apples. In some cases, however, the packer also lines the boxes, although this is often the work of a waiter or extra helper in the packing house.

The average number of packed boxes per day in the case of these 24 men is 55.7 per packer.

NAILING, ETC.

Seventeen of these 24 men make a practice of using one man for nailing alone, while seven combine nailing and waiting. For those who nail it was found that one man will do 312 boxes in 10 hours at a cost of \$0.0064 per box, while for those who nail and wait it is found that the average man will do 171 boxes in 10 hours at a cost of \$0.0117 per box.

Twelve of the packers have a waiter whose business it is to wait on the sorters and packers. This waiter will handle the boxes and wait on a crew putting out 260 boxes per day. The cost per box for this labor is \$0.0077. Nearly half of the men who pack their own apples either employ a packing-house foreman, or the owner himself acts in this capacity in addition to doing other packing-house labor. In these cases the packing-house foreman is employed separately from any packer or sorter. The cost per box for such men as have a foreman is \$0.0059, figured at the regular labor rate of \$0.20 per hour, although if the foreman is hired he is frequently paid at a higher rate. Many growers use still other packing-house labor. Such labor usually includes the man who helps truck the boxes and does various other things that are often done by waiters.

The total packing-house labor cost, including those who have their packing done at the association, is \$41.64 per acre, or \$0.1236 per box.

Both the associations and the growers generally use the Northwest diagonal pack. The extra fancy and fancy grades and often the C grades are wrapped. C grades, and sometimes fancy apples, in poor-price years, are packed but not wrapped. The distributors make a practice of wrapping all three grades. The association charge in such cases includes not only labor, but the box, paper, nails, etc., also the cost of handling the box, together with an inspection fee and sinking fund. However, in this study of costs only the actual packing and box costs are considered. Inspection, sinking fund, overhead expenses, etc., are items which are not taken into consideration in any of this cost-production work, since they are factors which ordinarily enter into the cost of marketing after the apples are delivered at the station.

All handling labor cost has now been discussed. If to the packing-house labor of \$0.1236 per box is added the cost of made-up box, including paper, nails, etc. (\$0.1585), there is a total material and labor cost per box of \$0.2821 within the packing house. If to this are added all other handling labor costs, there is a total for handling, including labor and material, of \$0.3612 per box, or after the culls are credited, it is reduced to \$0.3455 per box as a net labor and material cost.

CULLS AND CIDER APPLES.

Many growers sell a few tons of cider or drier apples each year. These are known as the "cull apples," and may come either from the packing shed or be picked up from the ground in the orchard. In the Payette region, however, very few growers pick up windfalls and sell them as cider apples. Most of the apples used for cider in this section

are separated from the better grades by the sorters in the packing house, as the price received hardly would warrant the labor of picking up the apples in the orchard. The price per ton varies, but is usually from \$5 to \$6, delivered at the cider factory. At present there is not a large enough demand for cider apples to justify handling all those available in the valley. A great many growers do not sell their cull apples, but feed them to hogs, valuing them at from \$3 to \$4 per ton as hog feed.

The credit per acre derived from culls averages \$5.40 for the orchards under the clean-cultural system and \$5.22 for those under the mulch-crop system. For all orchards there was a credit of \$5.29 per acre, leaving a net credit of \$4.61 after the labor cost of picking up and hauling culls is taken out. By crediting this, the cost of handling labor is reduced from \$0.2007 per box to \$0.1870 per box.

TOTAL LABOR COSTS.

The total of all labor costs after crediting the maintenance labor with the hay or pasture credit and the handling labor with the cull credit, is \$103.40 per acre, or \$0.3068 per box. (See Table XIV.) This is 43.14 per cent of the total annual net cost of production. The net maintenance labor costs \$40.38 per acre, or \$0.1198 per box, making up 16.84 per cent of the total annual net cost, while the net handling labor amounts to \$63.02 per acre, or \$0.1870 per box, and makes up 26.30 per cent of the total annual net production cost.

As may be seen from the labor table, the costs of thinning and pruning are the largest maintenance costs. They make up 18.32 per cent of the total net labor cost. These total labor costs are for an average of all the bearing orchards considered and are on the basis of a yield of 337 boxes per acre. The table is self-explanatory and shows the difference between the clean-cultural and mulch-crop orchards, there being a difference in the net maintenance costs of \$0.0229 per box, this cost being greater in the case of the clean-cultural orchards. However, for all net labor the cost per box is practically the same in both the clean-cultural and the mulch-crop orchards, being \$0.3085 in the case of the former and \$0.3054 in the case of the latter.

TABLE XIV.—Summary table of all labor costs, 38 farms in Payette Valley, Idaho.

Item.	Clean-cultural management (16 records; 336 boxes per record).			Mulch-crop management (22 records; 338 boxes per record).			Combined management (38 records; 337 boxes per record).			
	Cost per acre.	Cost per box.	Per cent of total net cost.	Cost per acre.	Cost per box.	Per cent of total net cost.	Cost per acre.	Cost per box.	Per cent of total net labor cost.	Per cent of total net cost.
Mannring.....	\$1.74	\$0.0052	0.74	\$1.94	\$0.0057	0.79	\$1.85	\$0.0055	1.79	0.77
Pruning.....	8.47	.0252	3.58	10.22	.0302	4.22	9.48	.0281	9.16	3.95
Disposal of brush.....	3.59	.0107	1.52	3.34	.0099	1.38	3.45	.0103	3.36	1.45
Plowing.....	1.44	.0043	.61	.42	.0013	.18	.85	.0025	.81	.35
Cultivating.....	7.93	.0236	3.35	2.30	.0068	.95	4.67	.0139	4.53	1.96
Irrigating.....	1.98	.0059	.84	1.79	.0053	.74	1.87	.0055	1.79	.78
Thinning.....	8.41	.0250	3.56	10.25	.0303	4.23	9.47	.0281	9.16	3.95
Propping.....	1.81	.0054	.77	2.87	.0085	1.19	2.42	.0072	2.35	1.01
Miscellaneous.....	1.23	.0037	.53	1.54	.0046	.64	1.41	.0042	1.37	.59
Lime-sulphur spray.....	2.44	.0072	1.02	2.64	.0078	1.09	2.56	.0076	2.48	1.06
Lead sprays.....	6.38	.0190	2.70	7.84	.0232	3.24	7.22	.0214	6.98	3.01
Sowing mulch crop.....				.01						
Harvesting mulch crop.....				1.87	.0055	.77	1.08	.0032	1.04	.45
Total labor cost previous to handling.....	45.42	.1352	19.22	47.03	.1391	19.42	46.33	.1375	44.82	19.33
Hay credit.....				9.27	.0274	3.82	5.37	.0160	5.22	2.25
Wood credit.....	.69	.0021	.30	.50	.0015	.21	.58	.0017	.55	.24
Total credit.....	.69	.0021	.30	9.77	.0289	4.03	5.95	.0177	5.77	2.49
Total net labor cost previous to handling.....	44.73	.1331	18.92	37.26	.1102	15.39	40.38	.1198	39.05	16.84
Hauling shooks.....	.68	.0020	.28	.46	.0014	.20	.55	.0016	.52	.23
Hauling loose boxes to and from orchard.....	5.27	.0157	2.23	4.13	.0122	1.70	4.61	.0137	4.46	1.93
Picking and orchard foreman.....	15.45	.0460	6.54	15.82	.0468	6.54	15.67	.0465	15.16	6.54
All packing-house labor.....	37.39	.1113	15.82	44.73	.1323	18.47	41.64	.1236	40.29	17.38
Hauling to station or association.....	4.60	.0137	1.95	5.56	.0165	2.30	5.16	.0153	4.99	2.15
Picking up and hauling culls.....	.94	.0028	.40	.50	.0015	.21	.68	.0020	.65	.28
Total labor cost for handling.....	64.33	.1915	27.22	71.20	.2107	29.42	68.31	.2027	66.07	28.51
Credit for culls.....	5.40	.0161	2.29	5.22	.0155	2.17	5.29	.0157	5.12	2.21
Total net labor cost for handling.....	58.93	.1754	24.93	65.98	.1952	27.25	63.02	.1870	60.95	26.30
Total net cost of all labor.....	103.66	.3085	43.85	103.24	.3054	42.64	103.40	.3068	100.00	43.14

MATERIAL AND FIXED COSTS.

Costs other than labor, including the material and fixed cost, amount to \$136.25 per acre, or 56.86 per cent of the total annual net cost of production. (See Table XV.) The material costs are made up of manure, spray materials (including lime-sulphur, lead, and other spray materials used), seed, and the cost of made-up box, including paper and nails. This material cost amounts to \$72.94 per acre, or \$0.2164 per box. It makes up 30.43 per cent of the total annual net cost of production. There was no appreciable difference between the material costs of the clean-cultural and mulch-crop orchards, the cost being \$0.2148 per box in the case of the clean-cultural and \$0.2176 per box in the case of the mulch-crop orchards. The cost of made-up

box is the largest single item of the material cost, amounting to \$0.1585 per box. This cost is made up as follows:

Cost of box shook	\$0.1100
Cost to make up	.0085
Cost of wrapping paper	.0275
Nails	.0036
Cost of cardboard	.0044
Cost of lining paper	.0045
Total	.1585

The spray material is the second largest material cost, the lime and sulphur costing \$7.29 per acre and the lead amounting to \$6.14 per acre, making a total spray-material cost of \$13.43 per acre, or a box cost of \$0.0398. This spray material makes up 9.84 per cent of the total material and fixed cost and 5.60 per cent of the total annual net cost of production. A commercial brand of lime and sulphur is used. The ordinary arsenate of lead paste is generally used, although a few growers use the dry lead.

TABLE XV.—*Summary table of material and fixed costs, 38 farms in Payette Valley, Idaho.*

Item.	Clean-cultural management (16 records; 336 boxes per record).			Mulch-crop management (22 records; 338 boxes per record).			Combined management (38 records; 337 boxes per record).			
	Charge per acre.	Charge per box.	Per cent of total net cost.	Charge per acre.	Charge per box.	Per cent of total net cost.	Charge per acre.	Charge per box.	Per cent of total material and fixed cost.	Per cent of total net cost.
Manure	\$6.17	\$0.0184	2.61	\$5.92	\$0.0175	2.44	\$6.03	\$0.0179	4.43	2.51
Lime and sulphur	6.98	.0208	2.96	7.51	.0222	3.10	7.29	.0216	5.34	3.04
Arsenate of lead (first spray) ..	1.94	.0058	.82	2.04	.0060	.84	2.00	.0059	1.46	.83
Other spray material	3.81	.0113	1.61	4.39	.0130	1.81	4.14	.0123	3.04	1.73
Seed			.12		.0004	.06		.0002	.05	.03
Cost of made-up box	53.26	.1585	22.53	53.57	.1585	22.13	53.41	.1585	39.20	22.29
Total material cost	72.16	.2148	30.53	73.55	.2176	30.38	72.94	.2164	53.52	30.43
Interest charge	46.50	.1384	19.67	50.91	.1506	21.03	49.05	.1456	36.01	20.48
Apple-building charge	2.87	.0085	1.21	3.13	.0093	1.30	3.02	.0090	2.23	1.27
Equipment charge	4.24	.0126	1.79	5.55	.0164	2.29	4.99	.0148	3.66	2.08
Sprayer hire			.70		.0021	.29		.0012	.30	.17
Tax	4.94	.0147	2.09	3.82	.0113	1.58	4.29	.0127	3.14	1.79
Insurance	.26	.0008	.11	.28	.0008	.11	.27	.0008	.20	.11
Water rent	1.78	.0053	.75	.91	.0027	.38	1.28	.0038	.94	.53
Total fixed cost	60.59	.1803	25.62	65.30	.1932	26.98	63.31	.1879	46.48	26.43
Total material and fixed costs	132.75	.3951	56.15	138.85	.4108	57.36	136.25	.4043	100.00	56.86

The third largest item of material cost is the manure. For all orchards an average of 4.02 tons per acre is applied annually, at a material cost of \$6.03 and a box charge of \$0.0179. This makes up

4.43 per cent of the total material and fixed cost and 2.51 per cent of the total annual net cost.

The other item of material cost is the seed, which amounts to but \$0.07 annual charge per acre over all orchards and \$0.12 per acre for those under mulch-crop orchards. This charge is for alfalfa, bluegrass, or clover seed, which is sown only occasionally.

Under fixed costs are included such items as interest on apple orchard, the apple-building charge, equipment (including spray-rig hire), taxes, insurance, and water rent. The fixed costs amount to \$63.31 per acre annually, or \$0.1879 per box. They make up 46.48 per cent of the material and fixed cost and 26.43 per cent of the total annual net cost of production.

The interest charge (\$49.05 per acre, or \$0.1456 per box) is larger than all other items combined, being 20.48 per cent of the annual net cost of production. The equipment charge is figured at the rate of 25 per cent annual charge on equipment investment. The greatest item of equipment investment is the spray rig, which practically all growers own and on which there is ordinarily a large depreciation. The fact that the depreciation charge appears low is due to the fact that all equipment is figured at present value, while under the discussion of spray rigs the depreciation and upkeep is figured on the original investment. The annual equipment charge per acre is \$5.40, or \$0.0160 per box, being 3.96 per cent of the total material and fixed cost, or 2.25 per cent of the total annual net cost of production. The spray rig makes up over 75 per cent of this annual equipment charge.

The material cost in the case of Payette is about the same per box as found in other Northwest apple regions. However, in the case of the fixed cost there is a much lower charge per acre and per box than in most other Northwest regions, due to the fact that the average investment in land is much lower. The equipment charge in the Payette region is also somewhat less than in more intensive and specialized regions, for the farms are larger and the tools, with the exception of the spray rig, are used for many other purposes than for orchard operations.

The total material and fixed cost, amounting to \$0.4043 per box, of which 53.52 per cent is for material and 46.48 per cent for fixed cost, represents all costs other than labor.

SUMMARY OF ALL COSTS CONSIDERED.

When all items entering into the annual net cost of production of apples on the 38 farms studied are considered, there is found to be a cost of \$0.7111 per box for all records, for clean-cultural orchards \$0.7036, and for mulch-crop orchards \$0.7162. It is thus found that

it costs slightly over 1 cent more per box for the mulch-crop than for the clean-cultural orchards. This difference in cost is principally due to the greater fixed costs on the mulch-crop orchards. It will be seen from Table XVI that the percentage of the various costs which go to make up the total cost is nearly the same in both kinds of records.

TABLE XVI.—*Summary of all costs for 38 farms in Payette Valley, Idaho.*

Item.	Clean-cultural management (16 records; 336 boxes per record).			Mulch-crop management (22 records; 338 boxes per record).			Combined management (38 records; 337 boxes per record).		
	Cost per acre.	Cost per box.	Per cent of total net cost.	Cost per acre.	Cost per box.	Per cent of total net cost.	Cost per acre.	Cost per box.	Per cent of total net cost.
Total net cost of labor previous to handling.....	\$44.73	\$0.1331	18.92	\$37.26	\$0.1102	15.39	\$40.38	\$0.1198	16.84
Total net cost of labor for handling.....	58.93	.1754	24.93	65.98	.1952	27.25	63.02	.1870	26.30
Total net cost of all labor.....	103.66	.3085	43.85	103.24	.3054	42.64	103.40	.3068	43.14
Total material cost.....	72.16	.2148	30.53	73.55	.2176	30.38	72.94	.2164	30.43
Total fixed cost.....	60.59	.1803	25.62	65.30	.1932	26.98	63.31	.1879	26.43
Total material and fixed costs.....	132.75	.3951	56.15	138.85	.4108	57.36	136.25	.4043	56.86
Total net cost.....	236.41	.7036	100.00	242.09	.7162	100.00	239.65	.7111	100.00
Total net cost on the tree.....	121.35	.3612	51.33	119.41	.3532	49.32	120.20	.3566	50.16
Total net cost of handling <i>a</i>	115.06	.3424	48.67	122.68	.3630	50.68	119.45	.3545	49.84

a Includes total net cost of labor for handling, cost of made-up boxes, and apple-building charge.

If the material and fixed costs are combined, the cost of the clean-cultural orchards is 56.15 per cent and of the mulch-crop 57.36 per cent of the total annual net cost of production. It is thus apparent that the cost of production varies but little under the two systems of management.

Seventy-one cents per box may be considered a fair figure for the cost of production in Payette Valley under normal prices for labor and material.

FACTORS AFFECTING THE ANNUAL COST OF PRODUCTION.

The principal factors which affect the cost are the same for Payette Valley as for all other apple regions studied thus far. The one which has the greatest effect upon the cost per box is the yield per acre. Table XVII serves to show the cost of production per acre and per box. Orchards having various yields are divided into 10 groups ranging from 122 to 572 boxes per acre in yield. The maintenance cost is found to remain practically the same per acre in the case of the high yields as in the case of the low, but the maintenance cost per box very materially decreases as the yield per acre increases. The handling and material box costs are little influenced by the yield, while the fixed cost, although remaining much the same per acre,

decreases very rapidly per box as the yield increases. This is as might be expected, since these fixed costs refer to those annual charges which have little or nothing to do with the upkeep of the orchard or the harvesting of the fruit.

Other factors affecting the cost are the size of the orchard, the system of orchard management practiced, the amount of credit derived from hay, wood, culls, etc.

In the case of the smaller yields the grower actually lacks considerable of making any interest on his investment. For instance, with a yield of 122 boxes per acre, and assuming that the grower gets \$0.80 for all grades of apples, which is much higher than he gets some years, he would lose 11.4 per cent on his investment in bearing apple orchard. However, with the yield of 221 boxes he makes 3.94 per cent, and with the yield of 331 he makes 8.84 per cent. For those orchards that yield 419 he makes 16.64 per cent, and for those that yield 572 he makes 38 per cent. This, it should be remembered, is on the basis of the grower receiving \$0.80 f. o. b. for all grades of box apples.

It should be stated in this connection that with the yield as high as 572 boxes, as is sometimes the case in heavy crop years, there is often a smaller profit per box than in years when the crop is light. This is due to the fact that most orchards have a full crop the same year. Thus, when the crop is light, apples are scarce, and the price is correspondingly high. When there is a heavy crop, apples are plentiful and often bring a very low price to the grower.

TABLE XVII.—*Summary table showing effect of yield upon cost (38 records).*

Item.	Groups.				
	150 boxes or less.	151 to 200 boxes.	201 to 250 boxes.	251 to 300 boxes.	301 to 350 boxes.
Average yields (packed boxes).....	122	177	221	271	331
Total net maintenance cost per acre.....	\$42.73	\$39.84	\$39.72	\$25.63	\$55.85
Total net maintenance cost per box.....	.3502	.2251	.1797	.0946	.1687
Total net handling cost per acre.....	19.29	37.76	42.95	49.46	68.72
Total net handling cost per box.....	.1581	.2133	.1942	.1825	.2076
Total net labor cost per acre.....	62.02	77.60	82.67	75.09	124.57
Total net labor cost per box.....	.5084	.4384	.3741	.2771	.3763
Total material cost.....	47.51	44.84	49.48	64.93	85.62
Total fixed cost.....	75.74	51.19	52.72	59.54	48.70
Total material and fixed cost per acre.....	123.25	96.03	102.20	124.47	134.32
Total material and fixed cost per box.....	1.0102	.6425	.4624	.4593	.4058
Total net cost per acre.....	185.27	173.63	184.87	199.56	258.89
Total net cost per box.....	1.5186	.9810	.8365	.7364	.7821

TABLE XVII.—*Summary table showing effect of yield upon cost (38 records)—Contd.*

Item.	Groups.				
	351 to 400 boxes.	401 to 450 boxes.	451 to 500 boxes.	501 to 550 boxes.	551 to 600 boxes.
Average yields (packed boxes).....	380	419	494	539	572
Total net maintenance cost per acre.....	\$43.25	\$35.36	\$34.80	\$57.49	\$45.09
Total net maintenance cost per box.....	.1138	.0844	.0704	.1067	.0788
Total net handling cost per acre.....	64.71	86.12	75.78	110.21	88.70
Total net handling cost per box.....	.1703	.2055	.1534	.2045	.1551
Total net labor cost per acre.....	107.96	121.48	110.58	167.70	133.79
Total net labor cost per box.....	.2841	.2899	.2238	.3111	.2339
Total material cost.....	75.48	82.61	102.40	105.39	114.83
Total fixed cost.....	83.58	74.16	57.01	82.35	59.73
Total material and fixed cost per acre.....	159.06	156.77	159.41	187.74	174.56
Total material and fixed cost per box.....	.4186	.3742	.3227	.3483	.3052
Total net cost per acre.....	267.02	278.25	269.99	355.44	308.35
Total net cost per box.....	.7027	.6641	.5465	.6594	.5391

The material and fixed charges, which make up all costs other than the labor costs, amount to \$136.25 per acre, or \$0.4043 per box. Material and fixed costs make up 56.86 per cent of the total annual net cost of production, which is \$0.7111 per box.

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January 14, 1918

A METHOD OF CALCULATING ECONOMICAL BALANCED RATIONS.

By J. C. RÜNDLES, *Scientific Assistant.*

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Economy in feeding is of prime importance to the feeder. It involves judgment in the selection of feeds as well as skill in the mixing of rations. The feeder may know that he needs a concentrate rich in carbohydrates or one rich in protein, yet be at a loss to determine the cheapest form of the desired concentrate to buy. Again, he may have certain feeds available and be unable to determine the most economical proportion in which they should be fed to give a ration of a desired nutritive ratio. This bulletin suggests ways in which these problems may be solved by fixed rule as they arise.

It is, of course, generally understood among students of nutrition that protein, carbohydrate, and fat content of a feeding stuff is not the only factor affecting its feed value. Proteins differ in their nutritive qualities, while some substances not included in the classes above mentioned are necessary to the proper maintenance of the bodily functions. The palatability and succulence of a feeding stuff has much to do with its value as a feed. Many feeding stuffs have physiological effects entirely apart from their nutritive qualities. Again, a ration may be perfectly balanced from the standpoint of relative content of protein and energy producers, and yet be quite impracticable because too bulky or too concentrated. It is therefore understood that any consideration of a feeding stuff or a ration

based only on chemical composition is to be taken merely as a guide, to be followed in the light of all the knowledge obtainable about animal nutrition.

NEW METHOD OF BALANCING RATIONS.

The method of balancing rations commonly used might well be called the "Cut and Try Method." It is faulty for the reason that it usually necessitates several trials to secure the desired result. By using the method described in these pages, balancing a ration is a simple matter of multiplication and division.¹

Table I gives the excess protein per pound for different protein feeds when used in rations of various nutritive ratios. To illustrate: A hundred pounds of dried brewer's grains contains 21.5 pounds digestible protein and 44.2 pounds digestible carbohydrates. A ration with a nutritive ratio of 1:4, requires only 11.05 pounds protein to balance 44.2 pounds of carbohydrates. Hence, in such a ration, 100 pounds of this feed contains 21.5—11.05, or 10.45 pounds of excess protein. The excess protein in a single pound is thus 0.1045 pound. (See Table I, column headed "Ratio 1 to 4," opposite brewer's grains, dried.) In rations having wider ratios the excess protein is proportionally greater.

Some of the figures in Table I are printed in italics. These represent deficiency instead of excess in protein. Thus, in a ration of ratio 1:4, a pound of rye is deficient in protein by 0.0798 pound, while in a ration of ratio 1:10, it has an excess of protein amounting to 0.0279 pound.

In like manner Table II shows the protein deficiency per pound for various carbohydrate feeds as compared with rations of specified nutritive ratios. The italic figures in this table represent excess protein. Thus, in a ration of ratio 1:4, a pound of buckwheat is deficient in protein by 0.0572 pound, while in a ration with ratio 1:10 it has an excess of 0.0257 pound of protein.

¹ The tables used in this bulletin are based upon Table III, Digestible nutrients and fertilizing constituents, in Henry's "Feeds and Feeding." It was necessary to include the digestible fat, with its equivalent fuel value ($2\frac{1}{2} \times$ carbohydrate) with the carbohydrate in order to prepare the tables. In proposing a mathematical method for balancing rations different from the one commonly employed, the same assumptions are made as in the case of the usual method, viz, that fats have two and one-fourth times the feeding value of the carbohydrates and that a pound of carbohydrates or protein has a uniform value whatever its source. The latter assumption is, of course, not strictly true. Proteins differ somewhat in their nutritive value, and sugars have nutritive and physiological effects somewhat different from those of starches. Nevertheless, the assumption of the equality of value of these nutritive elements in various feed stuffs introduces a no greater source of error in the method proposed in this bulletin than in the usual method of balancing rations.

The method of balancing rations described in this bulletin is based on the principle (alligation) proposed by Prof. J. T. Willard in Kansas Experiment Station Bulletin 115, but the method of applying this principle is different, and is believed to be simpler and more convenient, especially when several feeding stuffs are to be used in the ration.

TABLE I.—*The amount of excess protein per pound of given protein feeds when used in rations with the following specified nutritive ratios.*

Protein feeds.	Digestible—		Nutri- tive ratio 1.	Ratio 1 to 4.	Ratio 1 to 5.	Ratio 1 to 6.	Ratio 1 to 7.	Ratio 1 to 8.	Ratio 1 to 9.	Ratio 1 to 10
	Pro- tein, per 100 lbs. feed.	Car- bohy- drate, per 100 pounds feed. ¹								
I. Concentrates:										
Brewers' grains, dried.....	21.5	44.2	2.1	0.1045	0.1266	0.1413	0.1519	0.1597	0.1659	0.1708
Cottonseed meal, choice.....	37.0	41.2	1.1	.2670	.2876	.3013	.3111	.3185	.3242	.3288
Cottonseed meal, good.....	31.6	43.2	1.4	.2080	.2236	.2440	.2543	.2620	.2680	.2728
Cowpea seed.....	19.4	57.0	2.9	.0515	.080	.099	.1126	.1227	.1307	.1370
Distillers' grains, dry, corn.....	22.4	66.5	3.0	.0578	.091	.1132	.1290	.1409	.1501	.1575
Distillers' grains, dry, rye.....	13.6	52.8	3.9	.004	.0304	.088	.0606	.07	.0773	.0832
Dried blood.....	69.1	2.0	.03	.6360	.6870	.6876	.6881	.6885	.6888	.6890
Fish meal, high in fat.....	37.8	26.1	.7	.3128	.3258	.3345	.3407	.3454	.3490	.3519
Fish meal, low in fat.....	40.9	5.0	.1	.3965	.3990	.4007	.4019	.4028	.4034	.4040
Germ oil meal, (H. G.).....	16.5	66.0	4.0	.....	.033	.055	.0707	.0825	.0917	.099
Gluten feed (H. G.).....	21.6	59.1	2.7	.0682	.0978	.1175	.1316	.1421	.1503	.1569
Gluten feed (L. G.).....	15.1	68.6	4.5	.0205	.0118	.0367	.053	.0653	.0748	.0824
Linseed meal (N. P.).....	31.7	44.2	1.4	.2065	.2286	.2433	.2539	.2617	.2679	.2728
Linseed meal (O. P.).....	30.2	47.7	1.6	.1828	.2066	.2225	.2339	.2424	.2490	.2543
Malt sprouts.....	20.3	50.3	2.5	.0772	.1024	.1192	.1311	.1401	.1471	.1527
Meat and bone meal, 30-40 per cent ash.....	37.0	24.8	.7	.3080	.3204	.3286	.3346	.3390	.3424	.3452
Meat and bone meal, over 40 per cent ash.....	30.9	22.1	.7	.2538	.2648	.2722	.2774	.2814	.2844	.2869
Peanuts with hulls.....	18.4	88.7	4.8	.0378	.0666	.0362	.0573	.0731	.0854	.0953
Peanut cake from hulled nuts.....	42.8	36.6	.9	.3365	.3548	.3670	.3757	.3823	.3873	.3914
Rye.....	9.8	71.1	7.2	.0798	.0442	.0260	.0636	.01	.02	.0279
Rye middlings.....	12.6	62.5	5.0	.0302	.001	.0218	.0367	.0479	.0546	.0635
Soy-bean seed.....	30.7	55.2	1.8	.1690	.1966	.2150	.2281	.2380	.2457	.2518
Tankage, 55-60 per cent.....	54.0	28.6	.5	.4685	.4828	.4923	.4991	.5042	.5082	.5112
Tankage, 45-55 per cent.....	48.0	30.8	.6	.4030	.4184	.4287	.4360	.4415	.4458	.4492
Tankage, below 45 per cent ash.....	37.6	37.6	1.0	.2820	.3008	.3133	.3223	.3290	.3342	.3384
Velvet-bean seed.....	18.1	62.7	3.5	.0242	.0556	.0765	.0914	.1026	.1113	.1183
Wheat flour middlings.....	15.7	62.5	4.0	.0008	.032	.0529	.0677	.0789	.0875	.0945
Wheat bran, winter.....	12.2	47.4	3.9	.0035	.0272	.043	.0543	.0627	.0693	.0746
Wheat shorts, standard, wheat middlings.....	13.4	55.9	4.2	.0058	.0222	.041	.0541	.0641	.0719	.0781
II. Roughage:										
Alfalfa hay.....	10.6	41.0	3.9	.0035	.024	.0376	.0474	.0547	.0601	.065
Alfalfa meal.....	10.2	40.5	4.0	.0008	.021	.0345	.0441	.0514	.057	.0615
Clover hay, alsike, all analyses.....	7.9	39.4	5.0	.0195	.0002	.0133	.0227	.0298	.0352	.0396
Clover hay, crimson.....	9.7	39.0	4.0	.0005	.019	.032	.0413	.0482	.0537	.058
Clover hay, red, all analyses.....	7.6	43.3	5.7	.0322	.0106	.0038	.0141	.0219	.0279	.0327
Clover hay, sweet, yellow.....	10.0	37.0	3.7	.0075	.026	.0383	.0471	.0538	.0588	.063
Clover hay, sweet, white.....	10.9	39.8	3.7	.0095	.0294	.0427	.0521	.0592	.0648	.0692
Cowpea hay, all analyses.....	13.1	35.9	2.7	.0412	.0592	.0712	.0797	.0861	.0911	.0951
Molasses alfalfa feeds.....	8.5	42.1	5.0	.0202	.0008	.0148	.0249	.0324	.0382	.0429
Peanut-vine hay with shells.....	9.6	58.3	6.1	.0498	.0206	.0012	.0127	.0231	.0312	.0377
Peas and oat hay.....	8.3	40.5	4.9	.0182	.002	.0155	.0251	.0324	.038	.0425
Skim milk, centrifugal.....	3.6	5.5	1.5	.0223	.025	.0268	.0281	.0291	.0299	.0305
Soy bean hay.....	11.7	41.9	3.6	.0122	.0332	.0471	.0571	.0646	.0704	.0751
Velvet bean hay.....	12.0	43.5	3.6	.0112	.033	.0475	.0579	.0656	.0717	.0765
Vetch hay.....	11.6	46.4	4.0	.....	.0232	.0387	.0497	.058	.0644	.0696

¹ The carbohydrate includes the fat with its usual fuel value ($2\frac{1}{2}$ times carbohydrate in Tables V and VI). Reference: Table III, Digestible nutrients and fertilizing constituents, Henry's "Feeds and Feeding."

The use of Tables I and II in balancing rations is illustrated in the following examples:

1. How much cottonseed meal is required to balance a dairy ration consisting of 30 pounds corn silage, 10 pounds alfalfa hay, and 3 pounds corn meal, giving a nutritive ratio of 1:6?

Solution:

	Protein.	
	Excess.	Deficiency.
30 pounds corn silage.....		0.5010
10 pounds alfalfa hay.....	0.3760	
3 pounds corn meal.....		.1776
Subtracting.....	.3760	.6786 .3760
1 pound cottonseed meal, excess.....	.3013	.3026
Pounds cottonseed meal required.....		1

TABLE II.—The amount of protein deficiency per pound of given carbohydrate feeds in rations with the following specified nutritive ratios.

Carbohydrate feeds.	Digestible—		Nutri- tive ratio 1.	Ratio 1 to 4.	Ratio to 5.	Ratio 1 to 6.	Ratio 1 to 7.	Ratio 1 to 8.	Ratio 1 to 9.	Ratio 1 to 10.
	Pro- tein.	Car- bohy- drate.								
I. Concentrates:										
Barley.....	9.0	70.4	7.8	0.086	0.0508	0.0273	0.0106	0.002	0.0118	0.0196
Beet pulp, dry.....	4.6	67.0	14.6	.1215	.088	.0657	.0497	.0377	.0284	.021
Broom-corn seed.....	8.3	68.7	8.3	.0888	.0544	.0315	.0151	.0029	.0067	.0143
Buckwheat.....	8.1	55.3	6.8	.0572	.0296	.0112	.002	.0119	.0196	.0257
Corn meal, chop, or shelled corn.....	6.9	76.9	11.1	.1232	.0848	.0592	.0409	.0271	.0164	.0079
Corn and cob meal.....	6.1	72.0	11.8	.1190	.083	.059	.0419	.029	.019	.011
Corn, oat, and barley feed.....	9.1	68.9	7.6	.0812	.0468	.0238	.0074	.0049	.0144	.0221
Durra grain.....	8.2	74.0	9.0	.1030	.066	.0413	.0237	.0105	.0002	.0080
Germ oil meal (L. G.).....	10.0	72.8	7.3	.082	.0456	.0213	.004	.009	.0191	.0272
Hominy feed (H. G.).....	7.0	77.6	11.1	.1240	.0852	.0593	.0409	.027	.0162	.0076
Hominy feed (L. G.).....	6.3	76.7	12.2	.1288	.0904	.0648	.0466	.0329	.0222	.0137
Kafir grain.....	9.0	71.0	7.9	.0875	.052	.0283	.0114	.0012	.0111	.0190
Milo grain.....	8.7	71.2	8.2	.0910	.0554	.0317	.0147	.002	.0079	.0153
Molasses feeds, below 10 per cent fiber.....	8.2	58.4	7.1	.064	.0348	.01533	.0014	.009	.0171	.0236
Molasses feeds, 10-15 per cent fiber.....	7.4	57.1	7.7	.0688	.0402	.0212	.0076	.0026	.0106	.0169
Molasses or blackstrap.....	1.0	58.2	58.2	.1355	.1064	.0870	.0731	.0628	.0547	.0482
Oats, ground (H. G.).....	9.1	60.6	6.4	.0575	.0272	.007	.0074	.0182	.0267	.0334
Oats.....	9.7	60.7	6.3	.0548	.0244	.0042	.0103	.0211	.0296	.0363
Rice, polished.....	8.0	74.1	9.3	.1052	.0682	.0435	.0259	.0126	.0023	.0059
Rice, rough.....	4.7	68.4	14.6	.1240	.0898	.067	.0507	.0385	.029	.0214
Rice bran (H. G.).....	7.9	57.9	7.3	.0658	.0368	.0175	.0037	.0066	.0147	.0211
Rye.....	9.9	71.1	7.2	.0788	.0432	.0195	.0026	.0101	.0200	.0279
Rye meal.....	9.2	70.5	7.7	.0843	.049	.0255	.0087	.0039	.0137	.0215
Sorghum grain.....	7.5	72.0	9.6	.1050	.069	.045	.0279	.015	.005	.003
Wheat, winter.....	8.7	71.0	8.2	.0905	.055	.0314	.0144	.0018	.0081	.0160
II. Roughages:										
Bluegrass, Kentucky, all analyses.....	2.3	16.2	7.0	.0175	.0094	.004	.0001	.0028	.005	.0068
Corn fodder, medium in water.....	3.0	50.7	16.9	.0968	.0714	.0545	.0424	.0334	.0263	.0207
Corn silage, well matured.....	1.1	16.6	15.1	.0305	.0222	.0167	.0127	.0098	.0074	.0056
Corn and clover silage.....	2.1	17.5	8.3	.0228	.014	.0082	.004	.0009	.0016	.0035
Corn stover, green, ears off.....	.5	12.4	24.8	.026	.0198	.0157	.0127	.0105	.0088	.0074
Kafir fodder, dry.....	4.1	48.8	11.9	.081	.0566	.0403	.0287	.02	.0132	.0078
Milo fodder, dry.....	1.9	42.6	22.4	.0875	.0602	.052	.0419	.0342	.0283	.0236
Millet, German.....	4.8	53.5	11.1	.0858	.059	.0412	.0284	.0189	.0114	.0055
Molasses-alfalfa feeds.....	8.5	42.1	5.0	.0203	.0008	.0148	.0249	.0324	.0382	.0429
Oat hay.....	4.5	41.9	9.3	.0598	.0388	.0248	.0149	.0074	.0016	.0031
Oat straw.....	1.0	44.6	44.6	.1015	.0792	.0643	.0537	.0458	.0396	.0346
Sorghum and cowpea silage.....	.9	18.0	20.0	.036	.027	.021	.0167	.0135	.011	.009
Sorghum dry fodder.....	2.8	49.3	17.6	.0953	.0706	.0542	.0424	.0336	.0268	.0213
Sweet sorghum, green.....	.7	15.5	22.1	.0318	.024	.0188	.0151	.0124	.0102	.0085
Sweet-corn fodder.....	5.9	50.5	8.6	.0673	.042	.0252	.0131	.0041	.0029	.0025
Soy beans and corn.....	1.7	15.0	8.8	.0205	.013	.008	.0044	.0018	.0003	.0020
Timothy hay, all analyses.....	3.0	45.5	15.2	.0838	.061	.0458	.035	.0269	.0206	.0155
Timothy and clover.....	4.0	42.2	10.6	.0655	.0444	.0303	.0203	.0128	.0069	.0022
Wheat hay.....	4.0	50.3	12.6	.0858	.0606	.0438	.0319	.0229	.0159	.0103
Wheat straw.....	.7	36.2	51.7	.0835	.0654	.0533	.0447	.0383	.0332	.0292

The excess or deficiency in protein of each feeding stuff in the above example is found first for one pound, in Table I or II, in the column headed "Ratio 1 to 6." The figures given in the table are then multiplied by the number of pounds of the respective feeding stuffs in the ration. Thus, in a ration with a 1:6 ratio, a pound of corn silage is deficient in protein to the extent of 0.0167 pound. (See Table II, column headed "Ratio 1 to 6," line beginning "Corn silage, well matured.") There being 30 pounds of silage, the total protein deficiency in silage is $0.0167 \times 30 = 0.5010$ pound. Subtracting the excess protein in 10 pounds of alfalfa (0.376 pound), the net deficit of protein is found to be 0.3026 pound. Dividing this by the excess protein in one pound of cottonseed meal, which is 0.3013 pound, we find that it takes almost 1 pound of the latter to balance the ration to a 1 to 6 ratio. After adding this pound of cottonseed meal, the balanced ration stands as follows:

	Protein.	
	Excess.	Deficiency.
30 pounds corn silage.....		0.5010
10 pounds alfalfa hay.....	0.3760	
3 pounds corn meal.....		.1776
1 pound cottonseed meal.....	.3013	
	.6773	.6786

Sometimes it may be desirable to balance a ration, not simply by adding a protein feeding stuff, but by substituting it for one less rich in protein. Suppose, for instance, that we desire to substitute enough cottonseed meal for corn meal in the above ration to make the nutritive ratio 1 to 6. In this case the ration is worked out as follows:

	Protein.	
	Excess.	Deficiency.
30 pounds corn silage.....		0.5010
10 pounds alfalfa hay.....	0.3760	
3 pounds corn meal.....		.1776
	.3760	.6786
		.3760
Net deficiency.....		.3026

Taking out 1 pound corn meal reduces deficiency..... 0.0592
 Adding 1 pound cottonseed meal reduces deficiency..... .3013

Total reduction per pound substituted..... .3605
 Pounds to be substituted, $0.3026 \div 0.3605 = 0.84$.
 Corn meal remaining after substitution, $3.00 - 0.84 = 2.16$.

The resulting ration is therefore:

	Protein.	
	Excess.	Deficiency.
30 pounds corn silage.....		0. 5010
10 pounds alfalfa hay.....	0. 3760	
2.16 pounds corn meal.....		. 1279
0.84 pound cottonseed meal.....	. 2531	
	. 6291	. 6289

2. When a ratio of 1: 6 is desired, how much alfalfa meal is required to balance a dairy ration of 35 pounds corn silage, 4 pounds corn meal, and 2 pounds cottonseed meal?

Solution:

	Protein.	
	Excess.	Deficiency.
35 pounds corn silage.....		0. 5845
4 pounds corn meal.....		. 2368
2 pounds cottonseed meal.....	0. 6026	
	. 6026	. 8213
		. 6026
Excess protein in 1 pound alfalfa meal.....		0. 0345) . 2187
Pounds alfalfa meal required.....		6. 3

3. In a ration for hogs it is desired to feed alfalfa meal and tankage in equal parts along with sufficient corn meal to give a nutritive ratio of 1 to 7. In what proportion should the feeding stuffs be mixed?

Solution:

	Protein excess.
1 pound tankage.....	0. 4991
1 pound alfalfa meal.....	. 0441
1 pound corn meal, deficiency.....	0. 0409) . 5432
Pounds corn meal required.....	13. 3

The proportion in which to mix the feeds is, therefore, tankage 1 pound, alfalfa meal 1 pound, and corn meal 13.3 pounds.

4. In order to secure a beef-feeding ration with a ratio 1 to 8, how much good cottonseed meal should be added to a ration consisting of corn silage 21 pounds, shelled corn 14 pounds, corn, oat, barley feed 3 pounds, and alfalfa hay 3 pounds?

Solution:

	Protein.	
	Excess.	Deficiency.
21 pounds corn silage.....		0.2058
14 pounds shelled corn.....		.3794
3 pounds corn, oat, barley feed.....	0.0147	.....
3 pounds alfalfa hay.....	.1641	.....
	.1788	.5852
		.1788
1 pound cottonseed meal, excess.....		0.2620) .4064
Pounds cottonseed meal required.....		1.55

HOW TO USE TABLES I AND II.

Given the desired nutritive ratio and a ration, or certain feeds in bulk to balance, proceed as follows:

(a) Turn to Table II. In the column representing the nutritive ratio desired find the protein deficiency for 1 pound of each of the carbohydrate feeds that are to be fed.

(b) For each feed multiply the protein deficiency per pound by the total quantity of that feed, add the products, and the sum is the digestible protein deficiency, or quantity required to balance the carbohydrate feeds.

(c) Turn to Table I. Note the amount of excess protein in 1 pound of each of the protein feeds to be fed given opposite the names of the feeds in the column representing the desired nutritive ratio.

(d) For each feed multiply the excess protein per pound by the total quantity of that feed, disregarding the one to be used for balancing the ration, and the sum of the products represents the total protein excess in the nitrogenous part of the feed or ration.

(e) Subtract the total amount of excess digestible protein furnished by the known quantity of the protein feeds from the total amount of protein required by the carbohydrate feeds and divide the difference by the excess amount of digestible protein furnished in 1 pound of the protein feed used for balancing the same.

TABLE OF EQUIVALENT PRICES.

It is often desirable in this connection to know what prices per bushel of grain correspond to hundred-weight values, and vice versa. For that reason Table III has been prepared.

TABLE III.—*Various values of grain per bushel and corresponding values per 100 pounds.*

Value per bushel.	Value per 100 pounds.							
	Wheat.	Rye.	Oats.	Barley.	Buck-wheat.	Corn, shelled.	Corn on cob.	Potatoes.
\$0.20			\$0.62					
.30			.94					
.40			1.25	\$0.83	\$0.83			\$0.67
.50		\$0.89	1.56	1.04	1.04	\$0.89	\$0.73	.83
.60	\$1.00	1.07	1.87	1.25	1.25	1.07	.88	1.00
.70	1.17	1.25	2.19	1.46	1.46	1.25	1.03	1.17
.80	1.33	1.43	2.50	1.67	1.67	1.43	1.18	1.33
.90	1.50	1.61	2.81	1.87	1.87	1.61	1.32	1.50
1.00	1.67	1.79	3.12	2.08	2.08	1.79	1.47	1.67
1.10	1.83	1.96	3.44	2.29	2.29	1.96	1.62	1.83
1.20	2.00	2.14	3.75	2.50	2.50	2.14	1.76	2.00
1.30	2.17	2.32	4.06	2.71	2.71	2.32	1.91	2.17
1.40	2.33	2.50	4.37	2.92	2.92	2.50	2.06	2.33
1.50	2.50	2.68	4.69	3.12	3.12	2.68	2.21	2.50
1.60	2.67	2.86	5.00	3.33	3.33	2.86	2.35	2.67
1.70	2.83	3.04	5.31	3.54	3.54	3.04	2.50	2.83
1.80	3.00	3.21	5.62	3.75	3.75	3.21	2.65	3.00
1.90	3.17	3.39	5.94	3.96	3.96	3.39	2.79	3.17
2.00	3.33	3.57	6.25	4.17	4.17	3.57	2.94	3.33
2.10	3.50	3.75	6.56	4.37	4.37	3.75	3.09	3.50
2.20	3.67	3.93	6.87	4.58	4.58	3.93	3.24	3.67
2.30	3.83	4.11	7.19	4.79	4.79	4.11	3.38	3.83
2.40	4.00	4.29	7.50	5.00	5.00	4.29	3.53	4.00
2.50	4.17	4.46	7.81	5.21	5.21	4.46	3.68	4.17
Bushels per 100 pounds.	1.667	1.786	3.125	2.083	2.083	1.786	1.471	1.667
Bushels per ton.....	33½	35½	62½	41½	41½	35½	29½	33½

HOW TO USE TABLE III.

The use of Table III can be well illustrated by examples. Given \$2.50 as the value of 100 pounds of barley, what is the corresponding value per bushel? Look for \$2.50 in column headed "Value per 100 pounds, barley." Opposite this value in column "Value per bushel" is given the corresponding value of barley per bushel, which is \$1.20.

RELATIVE VALUE OF FEEDS.

The selling price of a feed is not a reliable guide to its relative feeding value. The carbohydrate feeds (corn, oats, barley, kafir, and various others) and the protein feeds (cotton-seed meal, tankage, and brewers' grains) are found on the market at various prices. The feeder wants to know, with certain given prices, "What is the cheapest feed to buy—what is the true value of a bushel of oats, rye, or barley for feed when corn is worth 80 cents a bushel, or what is the value of a ton of brewers' grains, linseed meal, or bran when cotton-seed meal is worth \$30 per ton and corn a dollar a bushel?" In the following pages there are presented tables, by the use of which these questions can be answered.

RELATIVE VALUE OF PROTEIN FEEDS.

In localities in which the cheapest and most available feeding stuffs are deficient in protein and where, in consequence, it is necessary to buy nitrogenous concentrates as a means of balancing the ration, the feeder's problem is to obtain the needed protein with the smallest possible outlay of money. The method here outlined shows how this may be done.

TABLE IV.—To determine the relative cost of one pound of digestible protein in the protein feeds.

	Values, per ton, of corn containing similar amounts of carbohydrates and proportioned protein.											Pounds per ton digestible—		Proportional digestible protein.	Excess protein.
	\$8.21	\$9.24	\$10.26	\$11.30	\$12.32	\$13.34	\$14.37	\$15.40	\$16.42	\$18.48	\$20.53	Carbohy- hydrate.	Pro- tein.		
Value of corn per bushel, shelled.....	11.29	16.07	17.86	19.65	21.43	23.21	25.00	26.79	28.58	32.14	35.71	1.538	138	.....	.....
Value of corn per ton, shelled, 35½ bushels.....	88.21	130.24	142.66	158.92	175.18	191.44	207.70	223.96	240.22	271.82	303.38	153.8	138	.....	.....
I. Concentrate protein feeds:															
Brewers' grains, dried.....	7.66	8.61	9.57	10.53	11.49	12.43	13.40	14.35	15.30	17.22	19.11	88.1	430	79	351
Cottonseed meal, choice.....	8.03	9.03	10.03	11.01	12.04	13.04	14.05	15.05	16.04	18.06	20.06	82.1	710	74	666
Cottonseed meal, good.....	10.60	11.91	13.23	14.57	15.89	17.20	18.54	19.86	21.17	23.83	26.47	86.1	632	78	554
Cowpea seed.....	12.36	13.90	15.44	17.00	18.54	20.07	21.63	23.17	24.72	27.80	30.88	1,140	388	102	286
Distillers' grains, dry, corn.....	9.81	11.04	12.26	13.49	14.72	15.93	17.17	18.39	19.63	22.67	24.52	1,330	418	119	329
Distillers' grains, dry, rye.....	37	42	46	51	56	60	65	70	74	81	93	1,056	272	95	177
Dried blood.....	4.85	5.45	6.06	6.67	7.28	7.88	8.49	9.09	9.69	10.91	12.12	40	1,382	4	1,378
Fish meal, high in fat.....	13.53	15.22	16.90	18.61	20.30	21.97	23.67	25.36	27.07	30.43	33.81	522	756	47	709
Fish meal, low in fat.....	12.26	13.79	15.32	16.87	18.40	19.92	21.45	23.00	24.54	27.50	30.45	100	818	10	808
Germ oil meal (L. G.).....	12.08	12.35	13.72	15.10	16.48	17.84	19.22	20.59	21.95	24.71	27.45	1,156	200	131	69
Gluten feed (H. G.).....	12.75	14.34	15.93	17.53	19.12	20.70	22.31	23.90	25.48	28.68	31.86	1,320	330	118	212
Gluten feed (L. G.).....	8.21	9.24	10.26	11.30	12.32	13.34	14.37	15.40	16.42	18.48	20.53	1,372	302	123	179
Linseed meal (N. P.).....	8.86	9.97	11.07	12.19	13.30	14.40	15.51	16.62	17.72	19.91	22.15	88.1	634	79	555
Linseed meal (O. P.).....	9.35	10.51	11.68	12.86	14.02	15.18	16.36	17.52	18.68	21.03	23.36	95.1	604	80	318
Malt sprouts.....	4.61	5.18	5.76	6.34	6.91	7.48	8.06	8.64	9.21	10.37	11.52	1,006	406	90	316
Meat and bone meal, 30-40 per cent ash.....	4.11	4.62	5.13	5.65	6.16	6.67	7.19	7.70	8.21	9.24	10.26	496	710	44	696
Meat and bone meal, over 40 per cent ash.....	18.53	20.59	22.67	24.67	26.77	28.77	30.85	32.90	34.98	37.08	41.19	1,774	368	159	209
Peanut cake, with hulls.....	6.80	7.65	8.50	9.35	10.21	11.01	11.90	12.75	13.61	15.30	17.00	732	856	66	790
Peanut cake, with hulls and skins.....	11.62	13.06	14.51	15.97	17.42	18.86	20.32	21.77	23.21	26.13	29.02	1,250	614	112	140
Rye middlings.....	10.26	11.51	12.82	14.11	15.39	16.66	17.95	19.23	20.50	23.07	25.63	1,101	614	99	515
Soy-bean seed.....	5.21	5.98	6.64	7.31	7.97	8.63	9.30	9.96	10.62	11.96	13.28	572	1,080	51	1,029
Tankage, 55-60 per cent.....	3.72	4.44	5.15	5.87	6.58	7.29	8.00	8.71	9.42	10.73	12.04	616	962	55	907
Tankage, 45-55 per cent.....	6.99	7.86	8.73	9.60	10.48	11.35	12.23	13.10	13.97	15.72	17.46	752	752	67	685
Tankage, below 45 per cent.....	11.70	13.10	14.55	16.03	17.40	18.92	20.39	21.84	23.31	26.21	29.12	1,250	362	113	249
Vetiv-bean seed.....	11.61	13.06	14.51	15.97	17.42	18.86	20.32	21.77	23.21	26.13	29.02	1,250	314	112	202
Wheat flour middlings.....	8.81	9.91	11.01	12.12	13.22	14.30	15.41	16.51	17.61	19.81	22.01	918	244	85	159
Wheat bran, winter.....	10.39	11.68	12.98	14.29	15.58	16.87	18.18	19.46	20.76	23.37	25.96	1,118	268	100	168
Wheat short, standard wheat middlings.....	10.39	11.68	12.98	14.29	15.58	16.87	18.18	19.46	20.76	23.37	25.96	1,118	268	100	168

TABLE IV.—To determine the relative cost of one pound of digestible protein in the protein feeds—Continued.

	Values, per ton, of corn containing similar amounts of carbohydrates and proportioned protein.											Pounds per ton digestible—		Proportional digestible protein.	Excess protein.
												Carbohy- drate.	Pro- tein.		
II. Roughage protein feeds:	7.62	8.57	9.52	10.48	11.43	12.37	13.33	14.27	15.23	17.14	19.04	820	212	74	138
Alfalfa hay.....	7.33	8.46	9.40	10.35	11.29	12.22	13.17	14.11	15.01	16.93	18.81	810	204	73	131
Alfalfa meal.....	7.32	8.23	9.15	10.07	10.98	11.89	12.81	13.73	14.65	16.47	18.30	788	158	71	87
Clover hay, alsike.....	7.25	8.15	9.06	9.97	10.87	11.77	12.68	13.59	14.50	16.30	18.11	780	194	70	124
Clover hay, crimson.....	8.05	9.05	10.05	11.07	12.07	13.07	14.08	15.08	16.10	18.10	20.11	866	152	78	74
Clover hay, red.....	6.88	7.73	8.59	9.46	10.32	11.17	12.03	12.89	13.76	15.47	17.18	740	200	66	134
Clover hay, sweet.....	8.68	9.76	10.85	11.94	13.02	14.09	15.19	16.27	17.36	19.32	21.69	934	236	84	132
Clover hay, sweet, white.....	6.67	7.50	8.34	9.18	10.01	10.83	11.67	12.51	13.33	15.01	16.67	718	262	64	198
Cowpea hay, all analyses.....	7.82	8.80	9.78	10.76	11.74	12.70	13.69	14.66	15.61	17.60	19.55	842	170	76	94
Molasses, alfalfa feeds.....	10.83	12.19	13.54	14.90	16.25	17.60	18.96	20.31	21.67	24.37	27.07	1,166	192	105	87
Peanut-vine hay with nuls.....	2.23	2.51	2.79	3.07	3.34	3.62	3.90	4.18	4.46	5.02	5.57	240	48	21	27
Peas and oat hay.....	1.02	1.15	1.28	1.41	1.53	1.66	1.79	1.92	2.04	2.29	2.55	110	72	10	62
Skim milk, centrifugal.....	7.79	8.76	9.73	10.71	11.68	12.65	13.63	14.60	15.56	17.52	19.46	838	234	75	159
Soy-bean hay.....	8.08	9.09	10.10	11.12	12.13	13.13	14.15	15.15	16.17	18.18	20.20	870	240	78	162
Velvet-bean hay.....	8.62	9.70	10.77	11.86	12.94	14.00	15.09	16.17	17.25	19.40	21.55	928	232	83	149
Vetch hay.....															

NOTE.—It was necessary to include the fat with its usual equivalent value (24 times carbohydrate) with the carbohydrates, in order to devise Tables IV and V. Reference: Table III, Digestible nutrients and fertilizing constituents, Henry's "Feeds and Feeding."

As seen in Table IV, a ton of corn contains 1,538 pounds of carbohydrates and 138 pounds of protein, or 0.0897 pounds of protein for each pound of carbohydrates. Hereafter, in the discussion of this table, this 0.0897 pound of protein to each pound of carbohydrates is referred to as "proportional protein." It is the proportion of protein accompanying carbohydrates in corn.

A ton of dried brewers' grains contains 884 pounds of carbohydrates and 430 pounds of protein. Now, in corn, 884 pounds of carbohydrates would be accompanied by 79 pounds of protein ($884 \times 0.097 = 79$). The nutrients in a ton of dried brewer's grains may thus be classified as follows:

	Pounds.
Carbohydrates, 884 pounds, proportional protein.....	79
excess protein.....	351
Total protein.....	430

The digestible carbohydrate content of a ton of each of the various protein feeds is given in Table IV, first column to the right of the double rule. The digestible protein per ton is given in the next column. This is the sum of the proportional protein, given in next to the last column, and the excess protein, given in the last column. The proportional protein in choice cottonseed meal, for instance, which is 74 pounds, merely represents the protein obtained in corn along with 824 pounds of carbohydrates, which is the amount of the latter contained in a ton of choice cotton seed meal.

The method here outlined is based on the assumption that the carbohydrates and "proportional protein" in a ton of any expensive protein feed are worth just what they would cost in the cheap and standard carbohydrate feed used as a basis of comparison (corn in Table IV).

The first 11 columns of figures in Table IV give the value of the carbohydrates and proportional protein in a ton of each of the various nitrogenous feeds when the price of corn is as shown in the column headings.

When corn is worth more than a dollar a bushel, the value of the carbohydrate and proportional protein given in Table IV may be easily obtained by either combining the figures given in two columns or by adding to the values given in one column a proportional part of the values given in another. For example, when corn is worth \$1.50 a bushel, double the amounts given in column headed "\$0.75"; when it is worth \$1.15 a bushel add to the values given in column headed "\$1.00" one-third the amount given in column headed "\$0.45."

To illustrate the method of arriving at the cost of a pound of excess protein, let us assume that corn is 60 cents a bushel and peanut cake is \$30 a ton. In the column headed "\$0.60" we find

that when corn is 60 cents per bushel the carbohydrates and proportional protein in a ton of peanut cake are worth \$10.21. The excess protein in a ton of cake thus costs $\$30 - \$10.21 = \$19.79$. Since there are 790 pounds of this excess protein, a single pound costs $\$19.79 \div 790 = \0.025 , or 2.5 cents.

A few additional problems will show the facility with which computations may be made by use of this table.

1. Corn is available at 60 cents a bushel. Choice cottonseed meal can be bought at \$32 a ton and high-grade gluten feed at \$24. Which of the latter is the cheaper source of protein?

Solution:

Cottonseed meal.	Gluten feed.
\$32.00	\$24.00
¹ 11.49	¹ 16.48
² 666) <u>20.51</u>	² 326) <u>7.56</u>
0.0308	0.0232

Hence, gluten feed, under the conditions named, is the cheaper source of protein. It furnishes this element at 2.32 cents per pound, as against 3.08 cents for cottonseed meal.

In case the price of corn is not given exactly in the table, use the nearest price given. In this case the result will not be exact, but the inaccuracy will be of such nature that the result is never misleading.

2. With corn at 80 cents a bushel, choice cottonseed meal \$45 per ton, and tankage (45-55 per cent) \$50 per ton, which of the latter furnishes protein more cheaply?

Solution:

Cottonseed meal.	Tankage.
\$45.00	\$50.00
15.30	11.44
666) <u>29.70</u>	907) <u>38.56</u>
0.0446	0.0425

The \$15.30 and \$11.44 in the above solution are taken from Table IV, column headed "\$0.80"; the 666 and 907 are taken from the last column. Tankage is seen to be the cheaper source of protein at the prices given.

HOW TO USE TABLE IV.

Given a certain number of protein feeds with the local selling prices per ton, to determine the relative cost of protein per pound, proceed as follows:

1. In columns headed "Value of corn per bushel" select the one corresponding most nearly to the local market price of that grain.

2. In that column take the amount found opposite the name of the feed in question and subtract it from the local selling price of that feed. The difference represents the value of the excess carbohydrate.

¹ From column headed \$0.60 in Table IV. This figure is the value of the carbohydrates and proportional protein in a ton of the feed in question.

² From last column of Table IV. Pounds of excess protein in a ton of this feed.

3. In the last column opposite the name of the feed is given the amount of excess protein in a ton. Divide the value obtained above by this amount and the result is the value of a pound of excess protein, when bought in the feed considered.

RELATIVE VALUE OF CARBOHYDRATE FEEDS WHEN THE CHEAPEST AVAILABLE FEED IS NITROGENOUS.

In some sections of the country the most available feeding stuff is distinctly nitrogenous in character, and it is desirable to buy carbonaceous feeding stuffs to balance the ration. Thus, in the South, cottonseed meal is frequently the basic feeding stuff, while in many parts of the West alfalfa occupies this position. In such cases it becomes desirable to know the cheapest available source of carbohydrates. The method of procedure is given in the following pages. It is similar to that already given for evaluating protein feeds.

As seen in Table V a ton of choice cottonseed meal contains 740 pounds of digestible protein and 824 pounds of digestible carbohydrate, or 1.113 pounds of carbohydrate for each pound of protein. Hereafter, in the discussion of this table, this 1.113 pounds of carbohydrate to each pound of protein is referred to as "proportional carbohydrate." It is the proportion of carbohydrates accompanying protein in cottonseed meal.

A ton of barley contains 180 pounds of protein and 1,408 pounds of carbohydrate. Now, in cottonseed meal, 180 pounds of protein would be accompanied by 200 pounds of carbohydrate ($180 \times 1.113 = 200$). The nutrients in a ton of barley may thus be classified as follows:

	Pounds.
Proteins 180 pounds, proportional carbohydrates.....	200
excess carbohydrates.....	1,208
Total carbohydrates.....	1,408

The digestible protein content of a ton of each of the various carbohydrate feeds is given in Table V, first column to the right of the double rule. The digestible carbohydrate per ton is given in the next column. This is the sum of the proportional carbohydrate, given in next to the last column, and the excess carbohydrate, given in the last column. The proportional carbohydrate in dry beet pulp, for instance, which is 102 pounds, merely represents the carbohydrate obtained in cottonseed meal along with 92 pounds of protein, which is the amount of the latter contained in a ton of dry beet pulp.

The method here outlined is the same as that for Table IV. It is based on the assumption that the protein and the proportional carbohydrate in a ton of any expensive carbohydrate feed are worth just what they would cost in the cheap protein feed used as a basis of comparison (cottonseed meal in Table V).

TABLE V.—To determine the relative cost of 1 pound of digestible carbohydrate in carbohydrate feeds.

Value of cottonseed meal per ton ¹	Values per ton of cottonseed meal containing similar amounts of protein (and proportional carbohydrates).						Pounds per ton digestible—		Proportional carbohydrates.	Excess carbohydrates.	
	\$10.00	\$15.00	\$20.00	\$25.00	\$30.00	\$35.00	\$40.00	Protein.			Carbo- hydrates.
									740	824	
Barley.....	2.43	3.65	4.87	6.08	7.30	8.51	9.73	180	1,408	200	1,208
Beet pulp, dry.....	1.24	1.86	2.49	3.11	3.73	4.35	4.97	92	1,340	102	1,238
Broom-corn seed.....	2.24	3.36	4.49	5.61	6.73	7.85	8.97	166	1,374	185	1,189
Buckwheat.....	2.19	3.28	4.39	5.47	6.57	7.66	8.76	162	1,106	180	926
Corn, shelled.....	1.86	2.80	3.73	4.66	5.59	6.53	7.46	138	1,538	154	1,384
Corn and cob meal.....	1.65	2.47	3.30	4.12	4.94	5.77	6.59	122	1,440	136	1,304
Corn, oats, and barley feed.....	2.46	3.69	4.93	6.15	7.38	8.61	9.84	182	1,378	203	1,175
Durra grain.....	2.22	3.32	4.43	5.54	6.65	7.76	8.86	164	1,480	183	1,297
Germ oil meal (high grade).....	2.70	4.05	5.41	6.76	8.11	9.46	10.81	200	1,456	223	1,233
Germ oil meal (low grade).....	4.46	6.69	8.93	11.15	13.38	15.61	17.84	330	1,320	367	953
Gluten feed (high grade).....	5.84	8.76	11.69	14.59	17.51	20.43	23.35	432	1,182	481	701
Hominy feed (high grade).....	1.89	2.84	3.79	4.73	5.67	6.62	7.57	140	1,552	156	1,396
Hominy feed (low grade).....	1.70	2.55	3.41	4.26	5.11	5.96	6.81	126	1,534	140	1,394
Kafir grain.....	2.43	3.65	4.87	6.08	7.30	8.51	9.73	180	1,420	200	1,220
Milo grain.....	2.35	3.53	4.71	5.88	7.05	8.23	9.40	174	1,424	194	1,230
Molasses cane.....	.27	.40	.54	.68	.81	.95	1.08	20	1,144	22	1,122
Molasses alfalfa feeds.....	2.30	3.45	4.60	5.74	6.89	8.04	9.19	170	842	182	553
Molasses feeds, below 10 per cent.....	2.22	3.32	4.44	5.54	6.65	7.76	8.86	164	1,168	183	985
Molasses feeds, 10-25 per cent.....	2.00	3.00	4.01	5.00	6.00	7.00	8.00	148	1,142	165	977
Oats.....	2.62	3.93	5.25	6.55	7.86	9.18	10.49	194	1,214	216	998
Oats, ground (high grade).....	2.54	3.81	5.09	6.35	7.62	8.89	10.16	188	1,212	209	1,003
Rice bran.....	1.92	2.88	3.84	4.80	5.76	6.72	7.67	142	1,092	158	934
Rice, polished.....	2.16	3.24	4.33	5.40	6.48	7.57	8.65	160	1,482	178	1,304
Rice, rough.....	1.27	1.91	2.54	3.18	3.81	4.45	5.08	94	1,368	105	1,263
Rye.....	2.67	4.01	5.36	6.69	8.02	9.37	10.70	198	1,422	220	1,205
Rye meal.....	2.49	3.73	4.98	6.22	7.46	8.70	9.95	184	1,410	205	1,273
Sorghum, grain.....	2.03	3.04	4.06	5.07	6.08	7.10	8.11	150	1,167	167	1,273
Wheat, winter.....	2.35	3.53	4.71	5.88	7.05	8.23	9.40	174	1,420	194	1,266
Wheat bran, winter.....	3.30	4.94	6.61	8.24	9.89	11.54	13.19	244	948	272	676

¹ Composition based on choice cottonseed meal.

The first seven columns of figures in Table V give the value of the protein and proportional carbohydrate in a ton of the various carbohydrate feeds when the price of cottonseed meal is as shown in the column headings. When the value of cottonseed meal varies from that given in the column headings the value of protein and proportional carbohydrate can be made to correspond by increasing the figures in one of the columns a proportional amount. For instance, when cottonseed meal is worth \$12 per ton the figures in column headed \$10 should be increased by $\frac{1}{5}$, or 20 per cent.

To illustrate the method of arriving at the cost of a pound of excess carbohydrate let us assume that choice cottonseed meal is \$35 and dried beet pulp \$15 per ton. In the column headed "\$35.00" we find that when cottonseed meal is \$35, the protein and proportional carbohydrate in a ton of dried beet pulp are worth \$4.35. The excess carbohydrate in a ton of beet pulp thus costs $\$15 - \$4.35 = \$10.65$. Since there are 1,238 pounds of this excess carbohydrate, a single pound costs $\$10.65 \div 1,238 = 0.86$ cents. A few additional problems will show the ease with which computations may be made by use of this table.

Problem 1.—Choice cottonseed meal is available at \$35 per ton. Sorghum grain can be bought at \$20, rough price at \$28, and shelled corn at \$30.35, or 85 cents per bushel. Which is the cheapest source of carbohydrate?

Solution:

Sorghum grain.	Shelled corn.	Rough rice.
\$20.00	\$30.35	\$28.00
¹ 7.10	¹ 6.53	¹ 4.45
² 1273) 12.90	² 1384) 23.82	² 1263) 23.55
0.0101	0.0172	0.0186

Problem 2.—Given cottonseed meal at \$30 per ton and shelled corn at 95 cents per bushel, what is the value per ton of barley, oats, and rye for balancing a cottonseed meal ration?

Solution:

\$33.92	(Value of ton of corn at 95 cents per bushel. See Table III.)
5.59	(See Table V, column headed \$30, opposite corn, shelled.)
1384) 28.33	(For 1384, see last column Table V, opposite corn, shelled.)
0.0204	(Value of a pound of excess carbohydrates in corn.)

Barley: A ton of barley contains 1,208 pounds of excess carbohydrates, which, at 2.04 cents per pound, is worth \$24.64.³ The protein and the remaining carbohydrates are worth \$7.30. (See Table V, column headed "\$30.00," opposite barley.) Hence,

¹ See column headed "\$35.00" (Table V). These figures represent the value of the protein and proportional carbohydrate in a ton of these feeds when cottonseed meal is worth \$35 per ton.

² See last column, Table V.

³ It is assumed that a pound of excess digestible carbohydrate has the same value regardless of the feed which supplies it. When cottonseed meal is worth \$30 and corn 95 cents, a pound of excess carbohydrate has a value of 2.04 cents. This figure is used for determining the value of the excess carbohydrate in oats and rye. The value of the remaining carbohydrate content and the protein in these feeds is taken from Table V.

The proportional carbohydrate in barley, for instance, which is 696 pounds, merely represents the carbohydrates obtained in alfalfa hay along with 180 pounds of protein, which is the amount of the latter contained in a ton of barley.

As previously stated, the method here outlined is based on the assumption that the protein and "proportional carbohydrates" in a ton of any expensive carbohydrate feed are worth just what they would cost in the cheap protein feed used as a basis of comparison (alfalfa hay in Table VI).

The first 10 columns of figures in Table VI give the value of the protein and the proportional carbohydrates in a ton of the various carbohydrate feeds when the price of alfalfa hay is as shown in the column headings. Other figures to correspond to a different value of alfalfa hay may be easily obtained either by combining the figures of two columns in Table VI or by increasing those of one column by a proportional part of those in another column. For instance, when alfalfa is worth \$7, increase the figures found in column headed "\$6.00" by one-fourth of those found in column headed "\$4.00" to get figures corresponding to alfalfa at \$7.

To illustrate the method of arriving at the cost of a pound of excess protein let us assume that alfalfa hay is \$10 per ton and barley is available at \$22.88 a ton or 55 cents a bushel. In the column headed "\$10.00" we find that when alfalfa is \$10 per ton the protein and the proportional carbohydrate in a ton of barley is worth \$8.49. The excess carbohydrate in a ton of barley thus costs $\$22.88 - \$8.49 = \$14.39$. Since there are 712 pounds of excess carbohydrate, a single pound costs $\$14.39 \div 712 = \0.0202 , or 2.02 cents.

The use of Table VI is further illustrated in the following problem:

Alfalfa hay is available at \$12, shelled corn at \$25, barley at \$23, and milo grain at \$24 a ton. Which of the three grains is cheapest as a source of carbohydrates for balancing an alfalfa ration?

Solution:

Corn.	Barley.	Milo.
\$25.00	\$23.00	\$24.00
¹ 7.81	¹ 10.19	¹ 9.85
² 1004) 17.19	² 712) 12.81	² 751) 14.15
³ 0.0171	³ 0.0180	³ 0.01884

In this case, corn is the cheapest source of carbohydrates.

HOW TO USE TABLE VI.

Follow the directions given for the use of Table V.

¹ Table VI, column headed "\$12.00," opposite corn, barley and milo. These figures represent the value of the protein and proportional carbohydrate in a ton of the feeds in question.

² Table VI, last column.

³ Value of a pound of excess carbohydrates.

TABLE VI.—To determine the relative cost of one pound of digestible carbohydrate in carbohydrate feeds.

Value of alfalfa hay per ton ¹	Values per ton of alfalfa hay containing similar amounts of protein and proportional carbohydrates.										Pounds per ton digestible—		Proportional carbohydrates.	Excess carbohydrates.
	\$4.00	\$6.00	\$8.00	\$10.00	\$12.00	\$15.00	\$18.00	\$20.00	\$25.00	\$30.00	Carbollydrates.			
											Protein.	820		
Value of alfalfa hay per ton ¹											212	820	.....	.....
Barley.....	\$3.40	\$5.09	\$6.79	\$8.49	\$10.19	\$12.74	\$15.28	\$16.98	\$21.22	\$25.47	180	1,408	696	712
Beet pulp, dry.....	1.74	2.60	3.47	4.34	5.21	6.51	7.81	8.68	10.85	13.02	92	1,340	356	984
Buckwheat.....	3.06	4.58	6.11	7.64	9.17	11.47	13.76	15.28	19.10	22.92	162	1,106	627	479
Broom corn seed.....	3.13	4.70	6.27	7.83	9.40	11.75	14.10	15.66	19.57	23.49	166	1,374	642	732
Corn, shelled.....	2.60	3.91	5.21	6.51	7.81	9.77	11.72	13.02	16.27	19.53	138	1,538	534	1,004
Corn and cob meal.....	2.30	3.45	4.60	5.75	6.91	8.64	10.36	11.51	14.38	17.26	122	1,440	472	968
Corn, oat, and barley feed.....	3.43	5.15	6.87	8.58	10.30	12.88	15.45	17.17	21.46	25.75	182	1,378	704	674
Durra, grain.....	3.09	4.64	6.19	7.74	9.28	11.61	13.92	15.47	19.31	23.20	164	1,486	634	846
Germ of meal (H. G.).....	3.77	5.66	7.55	9.43	11.32	14.16	16.98	18.87	23.58	28.30	200	1,456	774	682
Germ of meal (L. G.).....	6.23	9.34	12.45	15.56	18.68	23.36	28.02	31.13	38.90	46.69	330	1,320	1,276	44
Hominy feed (H. G.).....	2.64	3.96	5.28	6.60	7.92	9.81	11.89	13.21	16.50	19.81	140	1,552	542	1,010
Hominy feed (L. G.).....	2.38	3.57	4.75	5.94	7.13	8.92	10.70	11.89	14.86	17.83	126	1,534	487	1,017
Kafir grain.....	3.40	5.09	6.79	8.49	10.19	12.74	15.28	16.98	21.22	25.47	180	1,420	696	724
Milo grain.....	3.28	4.92	6.57	8.21	9.85	12.32	14.77	16.42	20.51	24.62	174	1,424	673	751
Molasses cane or blackstrap.....	3.38	4.57	5.75	6.94	8.13	10.42	12.70	14.99	18.26	21.53	20	1,144	77	1,067
Molasses feeds below 10 per cent fiber.....	3.09	4.64	6.19	7.74	9.28	11.61	13.92	15.47	19.34	23.20	164	1,168	534	634
Molasses feeds 10-15 per cent fiber.....	2.79	4.19	5.59	6.98	8.38	10.48	12.57	13.96	17.45	20.94	148	1,142	572	570
Molasses alfalfa feeds.....	3.21	4.81	6.41	8.02	9.62	12.03	14.43	16.04	20.04	24.05	170	1,812	657	185
Oats, ground (H. G.).....	3.55	5.32	7.10	8.87	10.64	13.31	15.96	17.74	22.16	26.60	188	1,212	727	485
Oats.....	3.66	5.49	7.32	9.15	10.98	13.73	16.47	18.30	22.87	27.43	194	1,214	750	464
Rice, rough.....	1.77	2.66	3.55	4.43	5.32	6.65	7.98	8.87	11.08	13.30	94	1,368	364	1,004
Rice, polished.....	3.02	4.53	6.04	7.55	9.06	11.32	13.58	15.10	18.86	22.64	160	1,482	619	863
Rice bran.....	2.68	4.02	5.36	6.70	8.04	10.05	12.06	13.40	16.74	20.09	142	1,092	549	543
Rye.....	3.74	5.60	7.47	9.34	11.20	14.01	16.81	18.68	23.31	28.02	198	1,422	766	756
Rye meal.....	3.47	5.21	6.94	8.68	10.42	13.02	15.62	17.36	21.69	26.04	184	1,410	712	698
Sorghum, grain.....	2.83	4.24	5.66	7.07	8.49	10.62	12.74	14.15	17.68	21.22	150	1,440	580	860
Wheat, winter.....	3.28	4.92	6.57	8.21	9.85	12.32	14.77	16.42	20.51	24.62	174	1,420	673	747
Wheat bran, winter.....	4.00	6.91	9.21	11.51	13.81	17.27	20.72	23.02	28.77	34.52	244	948	944	4

¹ Composition based on all analyses.

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UNITED STATES DEPARTMENT OF AGRICULTURE
BULLETIN No. 638

Contribution from the Forest Service
HENRY S. GRAVES, Forester

Washington, D. C.



April 8, 1918

FORESTRY AND COMMUNITY
DEVELOPMENT

By

SAMUEL T. DANA, Assistant Chief of
Forest Investigations

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TOO LITTLE ATTENTION PAID TO SOME EFFECTS OF FOREST DEVASTATION.

Nowadays the more obvious results of forest devastation, such as fires, increase in soil erosion, and irregularity of stream flow, are pretty generally recognized. But so far comparatively little attention has been paid to certain economic and social effects of forest devastation, perhaps less apparent but scarcely less harmful. These are at once an indictment of the system that has made them possible and a challenge to devise a better one.

In a very literal sense our civilization has been built on wood. From the forests that once stretched almost unbroken from Maine to Florida, from the immense timber stands of the Lake States, and from those of the Rocky Mountains and Pacific coast has come, in turn, the material needed for the development of farms and the building of homes as settlement pushed ever westward. Unquestionably, the remarkable progress of agriculture has been made possible in large measure by an easily accessible supply of timber.

And along with the material for agricultural development the forests have given us also one of the greatest of our basic manufacturing industries. Of the 14 groups of industries recognized by the last census, the lumber industry stands third in number of wage earners and fourth in value of product. In its allied branches of logging, milling, and manufacture it employs 907,000 persons, or 13.7 per cent of all the wage earners in the country. The value of its annual

output of lumber and remanufactured products amounts to \$1,582,000,000. From the crude mills and moderate cuts of early days has come the modern mill of enormous capacity and elaborate equipment. To-day the lumber industry produces an annual cut of some hundred billion board feet of wood, furnishes a means of support for several millions of people, and in hundreds of ways is closely interwoven in the fabric of our economic life.

But there is another side to the picture. Too often has forest utilization been synonymous with forest destruction. Our forests, for the most part, have been used not as a crop, a renewable resource, but as a mine, which could yield its wealth but once and then must be abandoned. In many places when the forest "mine" became exhausted, the civilization and prosperity that forest exploitation brought about declined and disappeared. Other evils, inseparable from the system, also have followed in the wake of destructive lumbering. To point out some of the harmful economic and social effects and to suggest a remedy is the object of this bulletin. Before doing so, however, the reason for the destructiveness of ordinary lumbering operations in the United States will be touched upon briefly, since this offers a clue to the solution of the problem.

WHY OUR FORESTS HAVE BEEN DEVASTATED.

The chief reason why forest destruction rather than forest conservation has held sway in the United States is clearly the individualistic economic system under which the natural resources of the country have been utilized. The theory has been that individual initiative and self-interest, stimulated by the desire for pecuniary gain, could be trusted to secure the quickest and most nearly complete utilization of these resources, and that in the long run private ownership and development would result in the greatest good to the entire community. In line with this idea both the Federal and State Governments, until a comparatively few years ago, almost uniformly followed the policy of disposing of their forest lands as rapidly as possible. Enormous areas were sold, generally for a fraction of their real value, given away as railroad, highway, or other grants, and acquired—often for "homestead" purposes—under the various public-land laws. Within the last century several hundred million acres of forest lands in the United States have passed from public to private ownership.

Complete control over the bulk of the forests in the country has been turned over to thousands of private owners, each of whom has followed his own individual interest in handling his property. There has been no uniformity either in point of view or in practice. Some owners have cut conservatively, others recklessly, and still

others not at all. Probably the one idea which most owners have had in common was to adopt whatever course appeared to be the most profitable financially. Ordinarily, under the prevailing economic conditions, this meant cutting with entire disregard for the future. Enormous stands of apparently inexhaustible virgin timber were available, stumpage prices were low, and competition was keen. As a result the average lumberman was forced to conduct his business in the cheapest possible manner and very naturally felt no inclination to incur the additional expense necessary to secure closer utilization of timber, to provide for reforestation, or even to insure fire protection. This does not mean that the lumberman had less regard than other men for the needs of the future and for the rights of generations yet unborn, but merely that he was acting, in accordance with the necessities imposed by the accepted system, as his individual interests dictated.

The net result has been that in the handling of our forest resources forestry has been conspicuous by its absence. Little attempt has been made to keep forest land productive, and still less to secure a continuous yield of wood. Speculation in timber has been rife almost from the very beginning. Stumpage has been acquired for little or nothing, and profits in the lumber industry have been derived very generally from this source rather than from the logging and milling end of the business. Comparatively little thought has been given to the future, which has been left to take care of itself.

In the discussion that follows there is no desire to minimize the rôle that the lumber industry has played in opening up undeveloped regions and creating national wealth. It is not lumbering, but destructive lumbering, that calls for a remedy. And the responsibility for destructive lumbering rests not with any individual or group of individuals, but with an economic system that tends to hinder rather than to help permanent community development.

NEGLECTED EVILS OF DESTRUCTIVE LUMBERING.

A ROVING LUMBER INDUSTRY.

One of the most obvious economic effects of treating the forest as a mine rather than as a crop has been to make lumbering in the United States a roving industry, moving from one region to another as the timber resources of each in turn have been depleted. Not only have the States consisting chiefly of agricultural land, such as Ohio and Indiana, been largely cut out, but also those with large areas of land primarily valuable for forest production. New York State, for example, which in 1850 stood first in the amount of lumber produced, is now twenty-fourth. Pennsylvania, which was first in 1860, now stands eighteenth. Michigan, which held first place from

1870 to 1890, is now thirteenth. Wisconsin, which headed the list from 1900 to 1904, has now dropped to tenth place.

And so the lumber industry has migrated from one region to another as the center of production has shifted from the Northeast to the Lake States and then to the South, and is now shifting to the Pacific Northwest. This movement has been due in part to the normal clearing of land for agriculture and to the opening up and development of hitherto comparatively unsettled and inaccessible regions richly endowed with timber resources, but in part also to the fact that on most of the cut-over areas no steps were taken to secure a second crop to form the basis of another cut, and still less to provide for continuous forest production. The land to a large extent has been rendered unproductive, towns and farms have been abandoned, timber supplies have been depleted, transportation facilities have been crippled, and the community generally has been rendered poorer and less independent.

From a social standpoint one of the most significant phases of this lack of permanence in the lumber industry has been the influence that it has exerted on the movement of population and on the prosperity of cities and towns. Only in those regions where agricultural lands strongly predominate have cities originally built up by the lumber industry succeeded in maintaining an uninterrupted growth and prosperity as the lumber was cut out. Many cities less favorably situated with respect to agricultural lands have also succeeded in maintaining their existence as the timber has gone by the introduction of other industries, but often only after a more or less prolonged period of depression, and in any event with less prospect of attaining the development that would have been possible if the forest land tributary to them had been kept productive.

ABANDONED TOWNS.

But the effects of forest devastation on community development are seen most clearly in the smaller towns in the regions primarily adapted to timber production. Here deserted villages are signposts that too often mark the trail of lumbering operations. As in the mining regions of the West, towns spring up almost overnight, flourish for a few years until the adjacent timber is cut out, and then sink rapidly to inactivity or even complete extinction. Unlike mining towns, however, there is not the same necessity for their disappearance. Timber is a renewable resource, which can be so handled as to insure continuity of cut and therefore of industry.

In the mountain counties of Pennsylvania, particularly in the northern part of the State, one comes upon town after town that has declined with the passing of the forest. Run down and deserted houses still standing give an idea of the towns' former prosperity.

Six and eight room frame houses with up to half an acre of land can be bought for from \$200 to \$400.

Most striking of all, perhaps, is the rise and fall of Cross Fork, in the hills of southeastern Potter County. In the fall of 1893, before lumbering operations started, perhaps five or six families were living on the site where two years later stood a busy town. For some 14 years Cross Fork led a feverish existence while the forest wealth was stripped from the surrounding hills. The life of the town was, of course, the big sawmill, which had a daily capacity of 230,000 board feet and was up to date in every respect. In 1897 a stave mill was established also, and various other minor wood-using industries existed at different times. In its prime Cross Fork had a population of 2,000 or more and was generally known as one of the liveliest, most hustling places in the State. A branch line of the Buffalo and Susquehanna Railroad was built to the town. Stores of all kinds flourished. There were seven hotels, four churches, a Y. M. C. A. with baths and gymnasium, a large, up-to-date high school, two systems of waterworks, and two electric light systems.

But the prosperity of the town was as short-lived as the timber supply. In the spring of 1909 the big sawmill shut down for good. From then on the population dwindled rapidly. Fires became so frequent that the insurance companies canceled their policies. Five-room frame houses with bath were offered for sale for from \$25 to \$35 without finding a buyer. In the winter of 1912-13 the stave mill also ceased operations, and the next fall railroad service, which for sometime had been limited to three trains a week, stopped altogether. To-day the total population consists of but 60 persons. If it had not been for the State, which bought up the cut-over lands and has undertaken in earnest the work of reconstruction, the town would be as desolate as the surrounding hills. As it is, Cross Fork is now a quiet little hamlet, the merest shadow of its former self and without hope for an industrial and useful future until the timber grows again.

The cut-over lands of the Lake States tell the same story of temporary prosperity characterized by the rise and fall of mushroom towns. Immense tracts of little value for anything except timber production have been left dotted with deserted villages as the lumber industry devastated them and swept on. Meredith, for example, was once a prosperous town in the northeastern corner of Clare County, Mich., for which one looks in vain on any modern map. To-day its hotels are in ruins, the town hall has been moved elsewhere, the railroad which connected it with the outside world has been torn up, and its population has dwindled from 500 to 3.

In Oscoda County, Mich., the town of McKinley has met a similar fate. Unlike many other woods towns it never had a large sawmill, but was rather a distributing center for the surrounding region. It had railroad and machine shops, a small sawmill and a shingle mill cutting material for local use, and served as headquarters for adjacent lumbering operations. The usual assortment of schools, churches, stores, hotels, and saloons met the needs of the 500 or more people in the town itself, to say nothing of the 2,500 lumberjacks in the surrounding woods. To-day the town is nothing but a memory. A few deserted houses, the foundations of the old shops, and a population of three, one of whom is a county pauper, are all that is left of its former activity. Its prosperity departed with the forests that gave it birth.

Farther west, in Wisconsin, the same trail of deserted villages has been left in the wake of the lumber industry. If it were not for the summer tourists who, in spite of the desolation of the cut-over lands, are attracted to the region by the beauty of its lakes the decline of many of the towns would be still more marked. Throughout the region desolation and decay have followed the prosperity that lasted only as long as the timber.

DESERTED FARMS.

In some regions the practice of timber "mining" has actually tended to cause the abandonment of farms as well as of towns. Nearly everywhere the fullest use of the natural resources of the country demands that both forestry and agriculture be practiced, each in its appropriate place, since most regions contain both farm land and forest land, although of course in widely varying proportions. Even in the best farming districts there are usually certain areas that should be devoted to woodlots, and patches suitable for cultivation are found in regions composed mainly of absolute forest land. Where the cultivable land is rather scattered, of only medium quality, or at some distance from a satisfactory market, it is often necessary for the region to have some other industry in order to make farming practicable. Profitable returns can not be secured from the farm alone. In such regions permanent wood-using industries afford additional opportunities for the farmer to secure employment. They not only help to tide him over the difficult period when he is clearing his land and getting a start, but they also furnish an extra source of income after he has become well established. Moreover, the presence of a population permanently employed in the wood-using industries creates a strong local market for farm products. This often enables the farmer to dispose profitably of material that could not be shipped to a more distant market. Additional industries also help to secure

better transportation facilities. Not infrequently these various factors, either singly or in combination, are just enough to make the difference between success and failure for the individual farmer. Certain it is that where large areas of forest lands are interspersed with smaller areas potentially valuable for agriculture, the management of the forest lands on the basis of a sustained annual yield may be absolutely necessary for the development of the agricultural lands, and in any event will make their utilization more profitable.

Unfortunately, forest exploitation in the past has been such as to make this ideal conspicuous by its absence. Under the individualistic economic system of the past there has been an irresistible pressure on the majority of private owners to cut clear and then abandon their land. The result has been lack of permanence not only in wood-using industries but in many regions in farming also. However desirable the clearing of the forest may have been in regions chiefly valuable for cultivation, in regions where forest lands predominate it has in the long run hindered rather than helped agriculture.

In Pennsylvania, for example, during the decade from 1900 to 1910, a period of rising prices for farm products, the number of farms decreased nearly 5,000. At the same time the area of land in farms decreased more than 780,000 acres, and the area of improved land in farms more than 530,000 acres. While the total population of the State was increasing 21.6 per cent, the number of farms decreased 2.2 per cent and the acreage of total farm land 4.1 per cent. The lure of the city and the development of better lands elsewhere may partially explain these facts. It is significant, however, that deserted farms are a common sight in the once timbered mountains, and that their abandonment has followed the departure of the lumber industry. With the passing of the local market and the opportunities for outside employment, their owners found farming a precarious business.

It is entirely possible, furthermore, to go to an extreme in the deforestation of all lands that are suitable for agriculture and that eventually should be cleared and cultivated. There is no advantage in removing the forests and abandoning such lands before they actually can be put to use. Under present conditions, however, this course is by no means uncommon. In Wisconsin, for instance, the State Agricultural College estimates that there are now 10,000,000 acres of cut-over lands, of which three-fourths may be agricultural. At the present rate of improvement, however—50,000 acres annually—it will be 150 years before this entire area is brought under cultivation. In other words, if the land had been maintained in forest it would be possible to raise from one to three timber crops on

it before it could be utilized fully for agriculture. If forestry had been practiced on only three-fourths of this 10,000,000 acres, and if the annual growth had been only 300 board feet per acre, there would be an annual production of $2\frac{1}{4}$ billion board feet annually. This is almost exactly twice the present lumber cut of the State. The production of this amount of material would support a good-sized population, stimulate business, provide a market for local agricultural products, and offer employment to the settler during slack times on the farm. Clearly nothing has been gained and much has been lost by abandoning forest production on the land before the time for its cultivation was ripe.

There are large areas that once were used for farms, justifiably perhaps, but that under present conditions should be used for the production of timber crops. In New England and New York, for example, thousands of acres that were cultivated before the opening up of the more fertile lands farther west are now properly being allowed to revert to forest. This conversion is being permitted for the most part to take place in a haphazard fashion, and consequently is proceeding all too slowly and irregularly. Proper care of these areas would help greatly to increase their productiveness.

A somewhat similar situation exists in northern Georgia, where approximately 10 per cent of the mountainous land now being acquired by the Government for National Forest purposes consists of abandoned farm lands. Practically the entire farming community that had settled there moved out in a body to raise cotton on the level, sandy lands of the coastal plain. In nearly all parts of the country are tracts that formerly were settled, cultivated for a while, and then abandoned either because the land was inherently unsuitable for permanent farming or because more valuable lands elsewhere became available for settlement. As a general rule, there is more danger that attempts will be made to cultivate land better suited for timber crops than that really good agricultural land will be retained in forest.

LOCAL SHORTAGES OF TIMBER.

Thanks to the successive opening up of fresh sources of supply as the lumber industry has moved south and west, the United States has not yet experienced a general shortage of timber. Sufficient wood still is cut each year to meet the needs of the country. This is being done, however, at the expense of the forest capital, and is possible only because the country has been so fortunate as to have available for immediate use the accumulation of many centuries of forest growth. The best available estimates indicate that for many years the annual cut of wood products of all kinds has greatly



A VIRGIN FOREST OF HEMLOCK AND WHITE PINE IN WESTERN PENNSYLVANIA.
Stands of this kind are now rare and in their place are denuded, fire-swept areas.



F-23134A

FIG. 1.—CUT-OVER AND BURNED-OVER LAND IN NORTHERN PENNSYLVANIA.

This area was formerly covered with a heavy stand of conifers similar to that shown in Plate I. Forests of this sort were the source of busy, prosperous communities while the timber was being cut. The region is now practically deserted and the area covered with worthless fire cherry, aspen, and sweet fern.



F-23156A

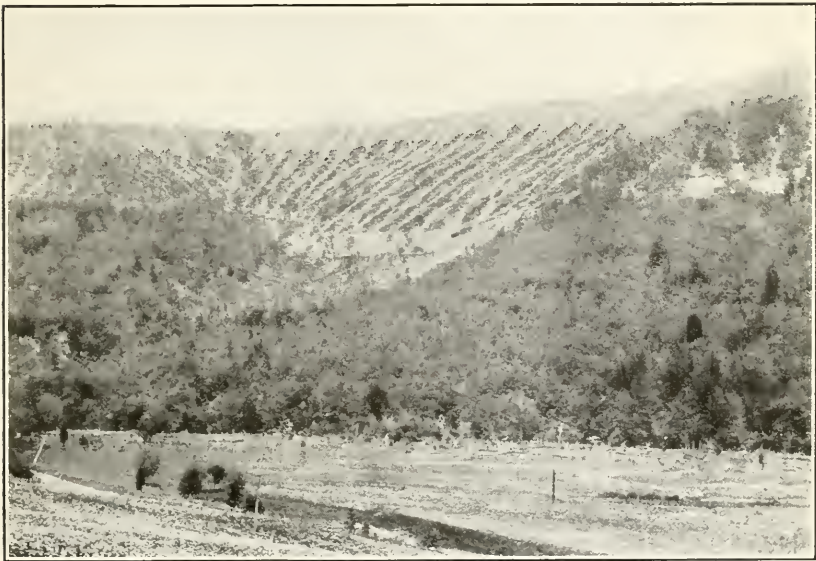
FIG. 2.—HOW PENNSYLVANIA IS BUILDING UP FOREST COMMUNITIES.

Many of the devastated lands are now the property of the State, which is attempting to reforest them and to build up permanent forest communities. At Pine Grove Furnace, in the heart of one of the State forests, all of the buildings in the town as well as the surrounding forest lands are owned by the State. The building shown in the picture has been repaired and improved, and is now rented for use as a hotel.



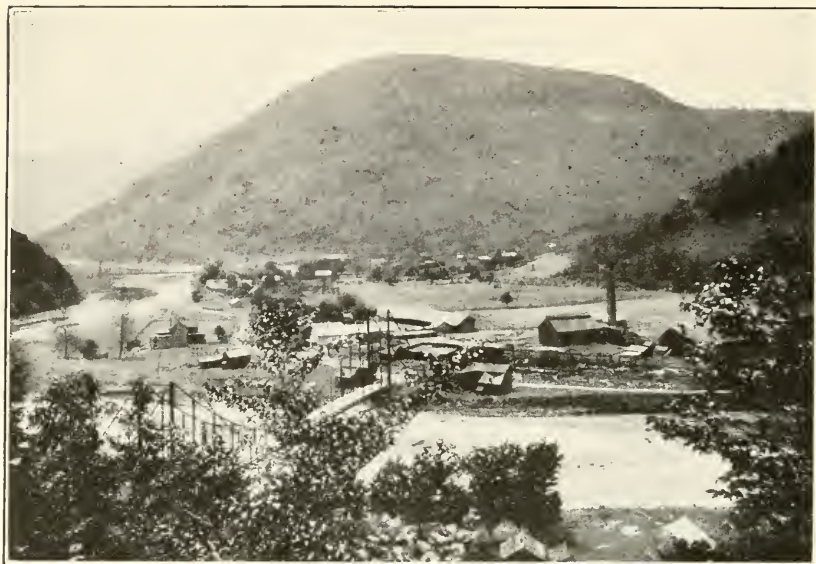
F-24319A

FIG. 1.—AN AREA CLEAR CUT FOR CHARCOAL FOR THE LEADVILLE, COLO., MINES.
Note high stumps, lack of reproduction, and erosion in right foreground.



F-23149A

FIG. 2.—A HILLSIDE CLEAR CUT FOR ACID WOOD IN NORTHERN PENNSYLVANIA.
The ruts down which the logs are dragged afford excellent opportunity for the starting of erosion.



F-23119A

FIG. 1.—GENERAL VIEW OF A PENNSYLVANIA TOWN, THE POPULATION OF WHICH FOR MANY YEARS WAS ABOUT 600, BUT IS NOW ONLY 40.

The tannery, on which the prosperity of the town depended, is shown at the right of the picture.



F-23117A

FIG. 2.—ANOTHER VIEW OF THE TANNERY, SHOWING MORE CLEARLY THE NUMBER OF DWELLINGS BY WHICH IT WAS SURROUNDED.

All of these buildings, like many others in the town, are now abandoned. Property values have depreciated materially with the departure of the forests.

exceeded the annual growth. Obviously, such a program can not be continued indefinitely. A few more decades will probably witness the exhaustion of the bulk of the virgin forests of the country except in the more inaccessible portions of the western States.

In the meantime in many parts of the country local shortages in standing timber have already occurred, with the consequent necessity of importing lumber from a distance and at correspondingly higher prices. Many regions which once were blessed with "inexhaustible" forest resources and from which vast quantities of lumber have been shipped now have to depend on other parts of the country for the bulk of their timber. Muskegon, Mich., formerly one of the largest sawmill towns in the world, offers a good example of this. In 1887 the sawmills of the town had a cut of more than 665,000,000 feet of lumber and 520,000,000 shingles; and it is estimated that the entire output of the forests tributary to the Muskegon River has exceeded 25 billion board feet. To-day lumbering operations have practically ceased. One small mill cuts some 3 or 4 million feet a year of inferior material picked up here and there along the shore of the lake. What lumber is used comes mainly from the South and from Wisconsin and Minnesota.

Depletion of local supplies has resulted very naturally in more or less marked increases in the prices of wood products in general. In spite of the fact that cheap stumpage has been available in other parts of the country, transportation charges have added materially to the cost of the lumber at the point of consumption. In the Middle West, for example, 20 per cent or more of the present retail price of lumber represents freight charges. Western lumber paying freights of from \$10 to \$18 per thousand board feet is a considerable factor in the supply of the East. Obviously, if the center of lumber production is to be located thousands of miles from the center of population, retail prices are bound to rise and the consumer must either pay the bill or go without.

The possibility of supplementing our own depleted forest resources from abroad has often been suggested optimistically but all too vaguely. Careful studies of foreign sources of supply seem to indicate that too much reliance should not be placed on this hope. Surplus supplies of timber still exist in Russia, Finland, and Sweden, but the growing demands of other European countries are almost certain to render comparatively little of this available for use in the United States. The forest resources of Central and South America are still to a large extent unknown, but it is very doubtful whether they can be counted on to supply us with any considerable amount of timber suitable for ordinary construction purposes. Canada still has a surplus, but this, too, is being rapidly depleted, and it is reason-

able to suppose that in the not distant future practically the entire production of its forests will be needed for home consumption by the constantly increasing population. Importations from any of these sources, moreover, involve considerable charges for transportation, with a corresponding increase in price to the consumer.

It seems certain that in the long run the United States must rely on its own resources to supply its needs for lumber, ties, paper, and other wood products, as well as for naval stores and wood distillation products. It is equally certain, furthermore, that these supplies should be produced as near the point of consumption as possible through the full use of forest land wherever it occurs. Too little attention has so far been paid to these fundamental truths. As a result, lumber prices have increased in the cut-over regions, and the pinch of inadequate supplies has already been felt in many localities.

SPECULATION.

IN STANDING TIMBER.

Speculation, both in standing timber and in cut-over lands, is another serious evil that has attended the exploitation of the forests. The subject is so big a one, however, as to make it impossible in a bulletin such as this to do more than touch briefly on a few of its more important aspects.

Large bodies of mature timber have been acquired with no intention of utilizing them immediately, but with the idea of trading them off as soon as possible at a substantial profit or of holding them for a rise in price. As transportation facilities have been developed and the country built up, there naturally has been a rapid rise in stumpage values, particularly in the newer sections. In parts of the Northwest, for example, the original price at which timber was acquired from the Government has been multiplied in subsequent transfers anywhere from ten to twenty times within the short space of ten or fifteen years. Millions of acres of the finest timberlands in the country passed every year from public to private ownership; hundreds of fortunes were made merely by buying and selling stumpage; and the entire tendency was to promote timber speculation at the expense of timber production. In a general way, although perhaps not in such acute form, this has been the history of timber ownership throughout the country. In fact, so rapidly have forest properties, originally acquired at little or no expense, increased in value that the lumber industry as a whole has looked for its profits to timber ownership rather than to logging and milling—that is, to the speculative rather than to the operative end of the business. Only too frequently have speculative returns concealed actual losses resulting from inefficiency of operation.

It has often been claimed that the incentive to make money by speculation has been one of the important factors in bringing about the development of many parts of the country, and particularly of the Western States. To what extent this is true depends on whether speculation is defined as a business venture involving considerable risk and therefore demanding a high interest return, or merely as an investment entailing no productive operations and depending for its profit on an expected increase in value. In the former sense, speculation undoubtedly has done much to open up previously unsettled portions of the country. In the latter sense, this may also be true of speculation in standing timber so far as such speculation has led to actual production as a means of realizing on the investment. Furthermore, it is obvious that the taxes paid by private owners of timberland, whether speculators or not, have aided materially in supporting local community improvements and governments. On the other hand, it may be open to question whether the development stimulated in these ways was always a normal and healthy one.

In many parts of the country, but particularly in the South and West, timber owners to-day find themselves in the position of having an overload of stumpage. Urged on by the belief that stumpage values were bound to rise indefinitely and that speculative profits are an inevitable consequence of timber ownership, they acquired enormous areas of forest lands, far in excess of the present needs of the industry. Contrary to expectation, these now have become a burden instead of an asset. Carrying charges, such as interest on the investment, taxation, and fire protection, in many cases are mounting up faster than the stumpage is increasing in value.

In California and the Pacific Northwest, for example, the capitalized value of privately owned timberlands is estimated at approximately \$1,100,000,000. Much of this is bonded, and on all of it carrying charges are heavy, while in recent years stumpage values have risen little or not at all. Consequently, all except the strongest owners have been forced to cut, irrespective of the demand, in order to meet current expenses and to retire their investment. In times of depressed market conditions the natural result of this has been to bring about a greater cut than the market can absorb at prevailing prices, with consequent failure of the weaker owners and general instability of the lumber industry.

From the standpoint of the manufacturer, overproduction begins when lumber prices do not return the cost of production plus a living profit. Curiously enough, this condition sometimes has accompanied a decrease in the total lumber cut. The explanation of this paradox lies in the fact that a decreasing demand for lumber, which is of course particularly marked in periods of general depression, means lower prices. In other words, the decreased demand that always ac-

companies poor markets may be more than sufficient to offset even a considerable decrease in supply. This was the case in western Washington in 1915, when overproduction was very marked in spite of a lumber production approximately 13 per cent less than that of 1913. In addition to the losses to manufacturers brought about by such a condition, this reduced cut probably meant a decrease of from \$7,000,000 to \$8,000,000 in wages paid to laborers, to say nothing of correspondingly decreased expenditures for supplies and equipment. Moreover, logging at such times is accompanied by a waste of much material in the woods, since depressed market conditions make it unprofitable to harvest the lower grades and inferior species. From the standpoint of the public, overproduction caused by timber speculation means the premature and wasteful exploitation of an essential resource, decreased opportunities for the employment of labor and investment of capital, and hard times generally for individuals and industries dependent on lumbering.

IN CUT-OVER LANDS.

Tying up agricultural lands.—Perhaps even more important from a social standpoint than the holding of mature timber is speculation in cut-over lands. This does not mean that such speculation has been universal. On the contrary, many owners, actuated by real public spirit, have attempted to secure the settlement of their cut-over lands under the right conditions or to hold them for future forest production. In spite of such instances, however, speculation in cut-over lands has been much too frequent, and has acted in two opposite directions: to prevent the development of good agricultural lands, and to encourage the settlement of nonagricultural lands. Whether such lands are put on or kept off the market depends entirely on the speculator, who naturally follows whichever course apparently will be most profitable for him, irrespective of its effect on the individual settler or on the community.

In the case of lands which are really suitable for agriculture, the tendency is for the speculator to hold them out of use in order to secure the benefit of the rise in land values that is sure to follow increase of population. This is done more often by offering the lands for sale at a price in excess of their true present value than by refusal to sell at any price. Examples of this practice, which generally is looked upon as "good business," are so common as scarcely to excite comment. A single illustration of how it works out in actual practice will therefore suffice.

In western Washington some 700,000 acres were eliminated from the Olympic National Forest in 1900 and in 1901 for the ostensible reason that the area was good agricultural land and that its reten-

tion under public ownership blocked development. The usual course of events then took place. The bulk of the land, which was for the most part heavily timbered, was at once taken up under the different land laws by "homesteaders," who immediately proceeded to dispose of it to various timber companies. Considerable areas were cut over by these companies, while other portions were held for speculation. Most of the cut-over lands have passed into the hands of land companies; a very small portion into the hands of bona fide settlers. Forty dollars and over per acre is asked for tracts that will require at least \$150 more per acre to clear. Fifteen years after the elimination of the area from the National Forest only some 600 acres out of the 700,000 had been put under cultivation. Timberland worth \$30,000,000 has passed from public to private ownership, and the development of the bulk of the area that is fitted for agriculture has been postponed indefinitely.

It is estimated that on the west coast of Washington and Oregon there are now some 4,000,000 acres of cut-over Douglas fir lands, and that this area is being added to at the rate of about 150,000 acres a year. Although a large part of this area consists of good agricultural soil, only a comparatively small portion of it has been put under cultivation, and the agricultural development of the region is proceeding much more slowly than its resources warrant. This is due in part to the high cost of clearing the land of stumps and logging debris, to lack of transportation facilities, and to distance from market. But all these difficulties are intensified by the speculative value placed upon the land, which often adds just enough burden to make its cultivation unprofitable and so to keep it out of use.

Selling sand barrens and swamps for farms.—In the case of non-agricultural cut-over lands there is little or no promise of a speculative rise in value, and the speculator usually disposes of them as rapidly as possible. Misrepresentation very often plays an important part in this. Dreary, sterile sand barrens and water-soaked swamps are pictured as fertile, wonderfully productive farm lands, as extraordinarily fine grazing grounds, or as the most delightful locations for summer resorts. Naturally, it is those who know least about such things who are ensnared most easily. Clerks, stenographers, mill hands, day laborers, and others from the city, who would have difficulty in making a living off the most fertile farm in the country, not infrequently invest all they have in the hope of being able to establish themselves independently on a piece of land of their very own. In such cases it is only a few years before inevitable failure forces them to abandon the land and return to their tasks with just a little less confidence in themselves, a little less hope for the future, and a great deal less faith in the honesty of their fellow man.

The sand plains of Michigan and Wisconsin are dotted with decaying dwellings and abandoned fields that tell the tale of the speculator in cut-over lands and his victims. Practically all these areas, which originally were covered with timber, were at one time the property of the State. Gradually, however, the bulk of them passed into the hands of private owners who proceeded to strip them of their timber. The cut-over lands were then sold to the so-called development companies or allowed to revert to the State for taxes. Large areas of these delinquent tax lands also fell into the hands of speculators through subsequent sale by the State. What happened to them can best be made clear by citing a few instances.

In Michigan, for example, until a few years ago the practice was for the State to sell, at an average price of approximately \$1 an acre, lands that had reverted to it through the nonpayment of taxes. A large proportion of these lands was acquired by speculators, many of whom were not even residents of the State, and who proceeded to use them as a means for exploiting the more credulous portion of the general public. It has been estimated officially that less than 5 per cent of the lands disposed of in this way were sold to actual settlers.

The land sharks naturally proceeded to realize on their investment as soon and as handsomely as possible. One lot of lands purchased from the State for an average of 86 cents an acre was sold for \$12 per acre, a profit of about 1,300 per cent. Still greater profits sometimes were made by the shrewd scheme of dividing the land into summer-resort lots consisting of from one-tenth to one-fourth acre, and selling these for from \$10 to \$15 a lot. Practically all these sales were made through misrepresentation. Full-page advertisements in the Chicago and Detroit papers and attractively illustrated pamphlets contained such statements as the following:

We have a glorious climate, the best water on earth, and easily cleared land which produces as much money per acre as any in the United States or Canada. Come and be one of us.

Roscommon County will grow more and better wheat, oats, rye, speltz, timothy hay, clover seed, beans, field peas, potatoes, cabbages, sugar beets, turnips, and rutabagas to the acre than any other county in the State, or in Illinois, Indiana, or Ohio.

Lands with such wonderful possibilities as these were to be had from the development companies for the nominal sum of \$6 and up per acre. To some extent they were bought as an investment, usually by city dwellers of small means, in anticipation of the rapid rise in value that surely would take place in lands so full of promise. Considerable areas, however, were bought by bona fide settlers. One land company stated that during the period from 1901 to 1907 more land in Roscommon and Crawford Counties was sold to active

farmers than in all the rest of the State together. These prospective settlers included both actual farmers who were attracted by the cheap price and ease of clearing, and clerks, stenographers, and other city workers who had no real knowledge of agriculture but were dazzled by the prospect of an easy and independent life. Needless to say, their expectations were not realized. As one of the State forest wardens expressed it:

A man will have more fun for his money by throwing it in the lake and seeing the splash. When these poor fellows from the cities buy a section of this land they expect to be able to grow something upon it. The result is that they eke out a miserable existence for a year or so, and then abandon the farm and are glad to get back to the city, where the pay envelope is handed out each Saturday night.

This does not mean that the entire region is nonagricultural; portions of it contain good land where farming is profitable. It does mean, however, that the lands which have reverted to the State for taxes and which form the principal stock in trade of the land companies have been classified naturally by a gradual culling process as the poorest in the region. They are chiefly light sands of the type concerning which one of the old-timers once said:

Of course you can farm those lands. All you need is two things—a shower of rain every week day and a shower of fertilizer on Sunday.

Not having sufficient control over the elements to bring about such a desirable combination, most of the would-be settlers sooner or later were forced to give up their attempts to cultivate land better suited for forest production than for farming. The result of the activities of the land speculators in forcing the settlement of nonagricultural lands in these regions has been described as follows by a man thoroughly familiar with local conditions:

I spent five days around Harrison and I saw abandoned farms in great numbers. I will bet I saw 100 farmhouses boarded up and desolate, and in some of them were the cook stoves, rocking chairs, and a lot of other stuff left behind, for they evidently had no money to cart it away. A whole lot of life's tragedy is written on the Michigan sand barrens. New settlers are going in right along to try the same old experiment of thrashing a living out of the sand and nothingness, and will meet with the same result.

A similar fate met those who invested in summer-resort lots, whether for speculation or for actual residence. A few of these were desirable locations on lake fronts, but the great majority were on desolate sand barrens or in impassable sphagnum swamps. These facts, of course, did not appear in the advertisements. Purchasers were led to believe that they were securing property of unusual attractiveness in a colony that was bound to be one of the most popular summer resorts in the State. In order to get the thing started and to secure the right kind of people prices were reduced at the

outset (to a point where the profit to the speculator would be only a few hundred per cent), or one or two extra lots would be thrown in as a bonus. Not infrequently it happened that when an owner came to look up his lot on the ground he found it in an entirely different location from that which he had been shown on the map.

A particularly pitiful case is that of a laundress from Chicago who bought a lot in a proposed colony that was to be one of the largest and most desirable in the State. As she thought the matter over, however, she became more and more convinced that one lot would not be sufficient to handle all of the business that she undoubtedly would have. So she looked up the promoter to see whether it would still be possible to add another to it. Yes, he would be glad to accommodate her, although the rate at which the property had been selling would necessitate a small advance in price. The laundress, of course, was delighted at her good fortune. Some time later, when she came to look up her property, she found that her original lot, like most of the others in the colony, was in the midst of a sphagnum swamp, and that the second one was a mile or more from it on the other side of a lake! The extent to which the colony actually developed may be judged from the fact that in the spring of 1916, 1,678 lots in the original "park" and its three "additions" were advertised for taxes in the local newspaper.

Statements made by land companies that 44,000 acres of land in the vicinity of certain lakes in Roscommon County changed owners between July 1, 1904, and June 1, 1905, and that up to February, 1908, about 40,000 people had bought lands and lots around Higgins Lake, may be true. Nevertheless, the fact that the population of the entire county in 1910, according to the census, was only 2,274 is sufficient proof that these activities did not result in really developing the region. As a matter of fact, permanent settlers have not been secured. Instead the land has been neglected and laid waste by fire, and little progress has been made in the production of the crop for which it is best suited—timber. Had the State adopted earlier its present policy of reserving for forest purposes all lands which revert to the State for nonpayment of taxes and which are nonagricultural, speculation in these lands would have been largely averted and a good start made toward restoring the forest and eventually building up permanent forest communities.

COMMUNITY DEVELOPMENT INTERRUPTED.

TOO FEW OR TOO MANY IMPROVEMENTS.

The amount of taxes contributed by the lumber industry in well-wooded regions has varied markedly from place to place. Instances are by no means unknown where receipts from taxes in lumber towns have been extraordinarily small in view of the amount of taxable

property in the town. Such property has belonged mainly to the large lumber companies, which were by far the best organized and the most powerful influence in the community. Seldom, under these circumstances, did the township officials impose a heavy tax rate or assess the company property at a sufficiently high value. As a result, the community did not have sufficient funds to pay for the improvements that its resources fully justified. Schools were cheaply built, poorly equipped, and manned with inefficient teachers; roads were badly constructed and their maintenance neglected; proper sanitation was not provided; and water and lighting systems were inadequate or entirely lacking.

On the other hand, instances also are known where towns with very similar conditions have gone to the other extreme in such matters. Schools, roads, and other public works have been constructed that were almost too good for the community. When this has happened, the bills have usually been paid, at least in part, not by increased taxation, but by issuing bonds or notes. Sometimes these have been made payable several years after the date of issue, sometimes on demand. In the latter case, however, it has been likely to happen that because of "financial difficulties" or for other reasons payment of the notes has been postponed from year to year. In either event it has often come about that the obligations have remained outstanding until after the departure of the lumber company, which, having had the benefit of the improvements, left them to be paid for in large part by others.

DEPRECIATION IN PROPERTY VALUES.

In addition to the general demoralization caused by such practices as these, the community is impoverished through the destruction of its most valuable resource. Only too often this has been the means of practically bankrupting communities in regions where land is of little value for anything except forest production. Thriving manufacturing towns have been succeeded by almost deserted villages. Taxable property has been reduced to a minimum. Not only this, but the value of the property that remains is impaired seriously as a result of the decrease in population. In towns where values have depreciated in this way it is not uncommon to find houses and lots offered for sale for amounts which shortly before, when prosperity abounded, would have been insufficient to pay more than a few months' rent.

Even in regions where the land is well suited for agriculture and eventually should be cleared for cultivation, too rapid removal of the forest may be detrimental because of its effect in reducing taxable values. All farming communities require a certain length of time

to become firmly established, and it is a great assistance if other industries are present to help tide over this preparatory period. In regions where the land is primarily valuable for forest production, the maintenance of the forest property in a productive condition is of course essential for the continued prosperity of the inhabitants.

It has been stated¹ that "there are in Pennsylvania several counties that were once prosperous, because rich in forest, but which are now reduced to an almost bankrupt condition because the timber is gone. The land is too poor and cold to encourage remunerative agriculture." Stewardson Township, in which is located the once busy sawmill town of Cross Fork, is in one of these counties. Assessed real estate values in this township dropped from \$896,862 in 1904 to \$18,815 in 1914—a decrease of 98 per cent in 10 years.² The precarious financial condition of the town is emphasized by the fact that it is still carrying a debt of several thousand dollars in school and road bonds left over from the days of its prosperity. If it had not been for the State, which for some years has been buying up cut-over land in that region, on which it has paid the township annually 2 cents an acre for schools and an equal amount for roads, bankruptcy would have been inevitable. As it happens, the \$1,645.60 paid to the township each year by the State has been sufficient to save the situation.

DELINQUENT TAX LANDS.

Still another aspect of the matter is that concerned with delinquent tax lands. In some sections of the country timberland owners have indulged in the practice of allowing their taxes to lapse for several years until they amounted to more than the value of the land, and then buying title from the State again for the nominal sum of \$1 an acre or thereabouts. This cheap way of paying taxes has meant, of course, a loss to the community approximately equal to the gain to the individual, in addition to the cost of advertising.

Advertising of such delinquent tax lands has in itself been a heavy expense to the State, though a material profit to the small country newspapers. In Michigan, for example, during the 10 years from 1896 to 1905, more than a million and a half dollars was spent for advertising delinquent tax lands and for extra clerical help in the auditor general's office. In the supplement to the *Roscommon Herald-News* for March 30, 1916, were published no less than 4,131 descriptions of land and lots in Roscommon County alone on which taxes were delinquent. Three thousand one hundred and seventy-four of these were for village and "resort" lots. The advertisements covered more than four and a half pages and must have been the source of considerable profit to the paper. In all probability the

¹ "Areas of Desolation in Pennsylvania," by J. T. Rothrock, 1915.

² See reports of the State Secretary of Internal Affairs in Pennsylvania.

expense incurred by the State in this advertising was almost a complete loss, since it is not likely that more than a very small per cent of the lands advertised, consisting for the most part of sand barrens and swamps, actually were sold.

Such conditions obviously tended to put a premium on fraudulent land dealing. Cut-over lands of little value except for forest production, for example, could be acquired cheaply by the speculator, divided into small lots, the smaller and more numerous the better, and sold as resort lots, fruit farms, or chicken ranches to persons unacquainted with local conditions. Almost any price would be sufficient to net a handsome profit. In addition the register of deeds would receive a tidy sum for recording transfers of title. Before long the purchasers would discover the true character of the land they had bought, taxes would be allowed to lapse, and the local newspapers would benefit substantially from the subsequent advertisement of delinquent tax lands by the State. Some years later the land again might be acquired by speculators and the same procedure repeated. Such transactions have proved highly profitable to speculators, newspapers, and registers of deeds, and equally unprofitable to the individual investor and the general public. At the same time the land has been withheld from the use to which it was best suited.

ABANDONED RAILROADS.

The way in which the forest resources of a region are handled has an important influence on the development and permanence of its transportation facilities. To a very considerable extent the lumber industry has been instrumental in connecting remote regions with the rest of the country. In some parts of the country practically every one of the main trunk lines of to-day started as a logging railroad. Lumbering was the only industry to call people to the region in any considerable numbers, and wood products were the only freight to come out. Where the land was valuable for agriculture, farming to a large extent succeeded lumbering. Often, however, there were no local markets for the farm crops raised on such lands, and it was only because transportation facilities, which had already been developed by the forest resources of the country, were available, that their successful utilization was possible. In other words, the forest by calling the railroads into existence made possible agriculture, which in turn made the railroads permanent.

In regions primarily adapted to forest production, destructive lumbering has a very different ultimate effect on transportation facilities. Here logging railroads in abundance are constructed while the timber is being exploited, and the most remote points are made easy of access. With the removal of the timber, however, the railroads

go too. Business dwindles away to little or nothing, and it is not long before the rails are pulled up and the region left inaccessible and desolate. Hundreds of miles of abandoned railroad grades with rotting ties are to be seen where the history of the lumber industry has taken this course.

In regions where large areas of absolute forest land are interspersed with patches of good agricultural land the same thing is true. Complete removal of the forest means a marked depreciation in the value of the farm land, if not its entire abandonment. With the timber gone, the amount of freight to be handled is reduced to such an extent that it may be unprofitable for the railroad to continue operation; and even if the railroad is maintained, the decreased business to be taken care of necessarily involves poorer service. If the forests were so handled as to insure continuous production, transportation facilities then could be maintained, agriculture developed wherever conditions were favorable, and the fullest possible utilization secured of all the resources of the region.

In this connection it is worth while to note that on land of average quality the production, in weight, of wood material is fully as great as, if not greater than, that of farm crops. Suppose, for example, that an acre of land will produce 1,500 pounds a year, dry weight, of wheat or oats, including both grain and straw. The same land, even if given practically no attention, should produce at least half a cord of wood a year, with approximately the same dry weight. If the forest is properly handled, however, it should be possible to double this yield, giving an advantage of 1,500 pounds in favor of the wood. On poor land, scarcely fitted for agriculture at all, the comparison undoubtedly would be even more favorable to the wood.

A LOWER STANDARD OF POPULATION.

One of the unfortunate results of the failure of lumber operations, as usually conducted, to build up well-organized, stable communities is seen both in the character of the population dependent on it and in that left on the cut-over lands after the industry has moved on.

The average lumberjack is a hardy, picturesque figure: but, moving from place to place and from region to region as the timber is cut out, he necessarily leads a roving, restless existence. A permanent home and a normal family life are impossible. In western Washington, for example, only 14 per cent of the employees in logging camps are married.¹ For these few the difficulties in the way of leading an orderly life, of maintaining a normal home, and of giving their children even a fair education are almost insuperable. A typical lumber

¹ "Need of Working Plans on National Forests and the Policies Which Should Be Embodied in Them," by B. P. Kirkland, in the Proceedings of the Society of American Foresters, Vol. X, No. 4.

camp, with its prevailingly rough, masculine population, its cheap buildings, and its frequent lack of sanitation, is by no means the best place in which to rear a family.

Nor are conditions greatly superior in the rude sawmill towns which flourish for a few years while the timber is being cut, only to fade away with its disappearance. Here there may be more of the elementary conveniences and decencies of life, but there is the same atmosphere of unrest, of instability, and even of immorality. The life of such towns is likely to be abnormal and their prosperity only temporary. Permanent homes, strong characters, and good citizens can not be built on so unstable a foundation.

As to the after effects of destructive lumbering, the scanty population left in the cut-over nonagricultural regions has little chance for development. Deserted villages and the barren lands by which they are surrounded not only offer little opportunity for employment but also exercise a depressing influence on the settler and his family. The men with most ambition, enterprise, and energy, the people who really accomplish things, move on to new fields, where they are not faced by the prospect of certain stagnation. It is usually the weaker ones who are left behind. Particularly serious is the effect of such deterioration on the coming generation.

Destructive lumbering also has its effect on the well-being of the city dweller by destroying his vacation ground. For the sportsman, the nature lover, and the recreationist, the conversion of a magnificent virgin forest into an ugly, stump-covered, and fire-blackened waste represents a very real loss. Not only have the trees themselves gone, but with them the flowers and ferns, the mosses and lichens, the birds and the deer, all that gave the woods their peculiar charm. Even springs may have gone dry and brooks become turbid and unlovely. From the mountains and the valleys, the streams and the lakes, man draws his inspiration and his strength; and to all of these the forest adds the final touch. Who cares to go fishing on a river or boating on a lake that has no trees? Without them something vital is lacking. A country once rich in forests can not allow them to be converted into unsightly wastes without paying a penalty, however intangible, in weakening the character of its population.

SUGGESTIONS FOR A RATIONAL TIMBERLAND POLICY.

NEED FOR A DIFFERENT SYSTEM OF HANDLING FOREST LANDS.

That, from a social standpoint, the system under which our forest resources have been handled in the past has not worked well is fairly clear. Sufficient lumber has been supplied to meet the needs of the country as a whole, but this has been done in such a way as to cause much waste and in certain localities to bring about local shortages of

timber. Forest regions have been well developed, provided with excellent transportation facilities, and made prosperous for a few years, only to be stripped of their timber and left desolate, poverty-stricken, and depopulated. Speculation and fraudulent land dealing have been practiced extensively. Permanent homes and normal family life have been the exception rather than the rule, and the standard of citizenship has been lowered.

For all these results the economic system adopted by the country, rather than the individual timber owner or operator, is of course primarily responsible. The individual was not only allowed, but actually encouraged, to follow whatever course would best advance his own interests; and if in doing so he brought about certain social and economic effects that were detrimental to the welfare of the community as a whole, the public has only itself to blame for the result.

The private owner very naturally did not feel that it was incumbent upon him to provide for the needs of future generations, nor did the adoption of such measures as would place the forest on a permanent producing basis appeal to him as an attractive investment. As a matter of fact, probably the great majority of private owners, and indeed of the general public, hardly thought of such matters at all, or if they did, it was generally with the easy feeling that the future would take care of itself. How it has done so in a number of important respects has been pointed out in the preceding pages.

It has often been argued that these results, regrettable as they are, could not have been avoided, because the country could have been developed at a satisfactory rate only by the individualistic "let-alone" system that was actually adopted. This statement is open to considerable question; but even if it is true, that is no reason why the system should still be continued. Economic conditions have changed completely within the last century, and, more important still, the general public now has an entirely different attitude toward problems that affect the community welfare. The tendency of the times is clearly to emphasize the social rather than the purely individualistic point of view. A system that may have been suited to the needs of the country a century or even a few decades ago may be distinctly unsuited to them now. This is very evidently the case so far as the "let-alone" system of handling our forest lands is concerned. From a community standpoint that system obviously has broken down. The problem now is to replace it by one that so far as possible will retain the good and eliminate the evil of the old system. Fundamentally this involves merely substituting the practice of forestry for timber "mining," but this in turn involves a number of different steps that deserve some further consideration.

LAND CLASSIFICATION.

The first step is to determine what lands should be devoted to forest production. As a basis for this, it would be extremely desirable to have a thorough classification of lands throughout the country made by competent public authorities. This classification should aim to point out the use to which the land is best adapted. Obviously it is an economic waste to grow trees on the best agricultural lands or to attempt to farm the poorest forest lands—so obvious, in fact, that the mistake is seldom made. But between these two extremes are all sorts of cases in which the economic waste of putting the land to the wrong use is less obvious but none the less real. On such lands as these a classification is particularly needed.

A great deal has already been accomplished in the way of soil and geological surveys. These are valuable so far as they go, but they do not go far enough. What is needed is not only information regarding the origin, composition, and depth of the soil, and the topography and climate of the region, but an interpretation of these factors in terms of their usefulness to man. The best present use of the land, furthermore, depends not only on the physical factors of soil and climate, but also on such economic factors as the availability and quality of agricultural lands elsewhere, the market for agricultural crops, transportation facilities, and the like. In the last analysis the problem boils down to such specific questions as these: Should this piece of land under present economic conditions be devoted to oak or to alfalfa? Should that piece be used for growing white pine or corn?

Such a classification as this, which of course should be conducted by representatives of the State or Nation, can not help involving many difficulties. Years ago it probably would have been impracticable; even to-day mistakes will be made. But that is no reason why the work should not be undertaken as promptly and pushed as rapidly as possible. A small start has already been made in this direction. In the National Forests, for example, no land is opened for entry under the homestead laws until it has been examined carefully to determine whether it really has agricultural possibilities. In the last few years surveys have been made of entire Forests, and on the basis of these surveys the land has been classified permanently as primarily valuable for agricultural or for forest purposes. In some of the State forest reserves agricultural settlement is not allowed at all or only after a thorough examination to determine the value of the particular tract of land for this purpose.

Many areas in every region can be classified almost at once as either agricultural (including grazing) or forest land. Many others will have to be classified as intermediate, by which is meant that they

may be devoted to either purpose as local conditions and the economic development of the region make one or the other more profitable. Undoubtedly many of these intermediate lands, perhaps most of them, for the present can be used most advantageously for the production of timber crops. A great deal of land that may properly be devoted to forest production to-day in all probability can be used more profitably for agriculture fifty years hence. Millions of acres of cut-over and timbered land in the Lake States, the Southern States, and the Pacific Northwest are of this character. An impartial land classification would recognize this fact and would designate them as primarily valuable, under present conditions, for forest purposes. This designation might well be changed in subsequent classifications, which would obviously be necessary from time to time in the case of intermediate and doubtful lands.

In making such a classification still another factor should be taken into account. This is the amount of land that should be retained in forest in order to prevent erosion and irregular run-off and to supply the country's needs for timber. Experience abroad has shown that countries with considerable hilly and mountainous land are likely to suffer from erosion and from alternating floods and low water when the forest is reduced to 20 per cent or less of the total area. Experience has also shown that approximately 100 acres of forest land per 100 inhabitants are necessary for a country to be self-sustaining as regards its wood supply, even with a much smaller per capita consumption of wood than exists in the United States. Both these facts can well prove useful to the Nation and to individual States as a guide in determining the extent to which they should allow their forest areas to be reduced.

After a land classification has once been made, the next step is to see that the land is actually used for the purpose to which it is best adapted. At first sight it might appear to be sufficient to publish the result of the classification and then to leave the matter entirely to the private owner, since he naturally would be inclined to devote the land to that use which would bring him the highest returns. It is doubtful, however, whether this is a safe assumption. Taking human nature as it is, it seems more likely that ignorance and prejudice would still lead in many cases to the wrong use of land, and, worse still, that a desire for speculative gains would frequently lead to its nonuse. State supervision of land-settlement enterprises, on the general principle of the "blue-sky laws" now applied in many States to the operations of corporations seeking to sell securities, probably would go far toward protecting the innocent but ignorant settler or investor; and a system of taxation that would absorb at least the greater part of the rental value that the land



FIG. 1.—ALL THAT IS LEFT OF THE ONCE PROSPEROUS TOWN OF CROSS FORK, PA.
With the departure of the sawmill its population shrank from 2,000 to 61, and the assessed value of its real estate from \$896,862 to \$18,815.

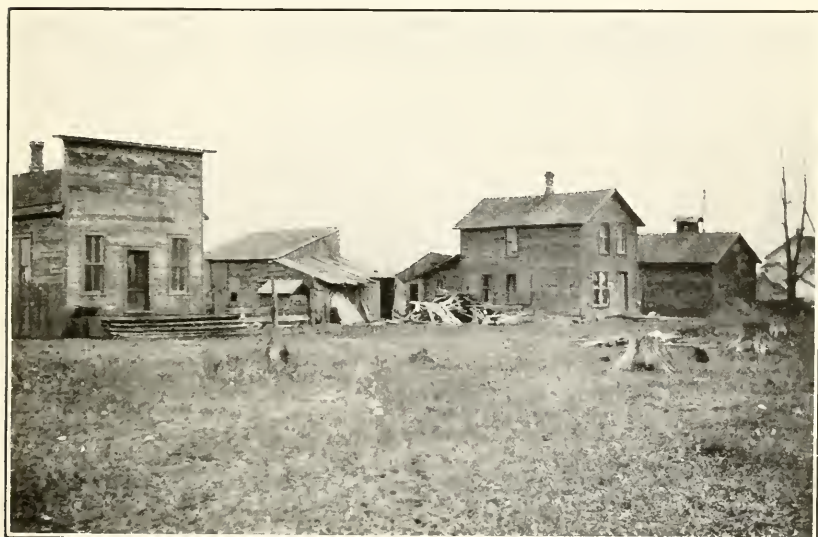
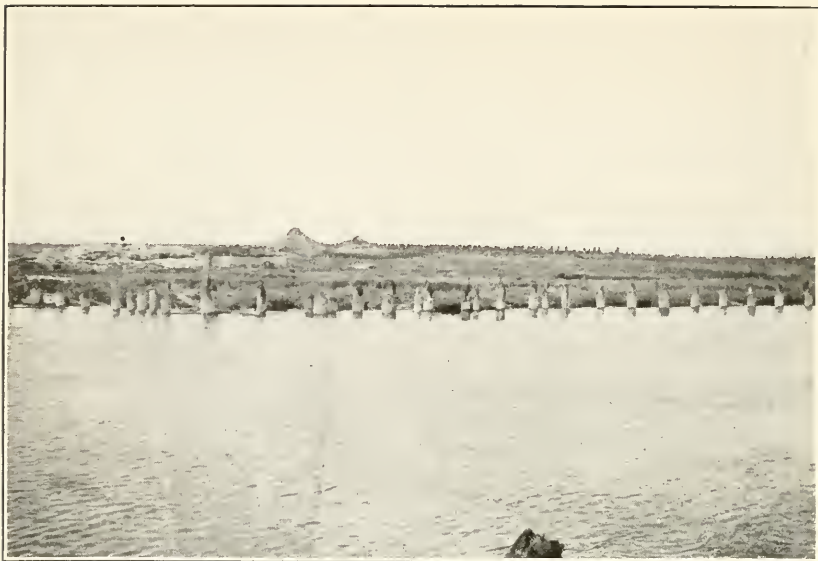


FIG. 2.—APPROXIMATELY HALF OF THE HOUSES IN THIS MICHIGAN TOWN ARE NOW
DESERTED.

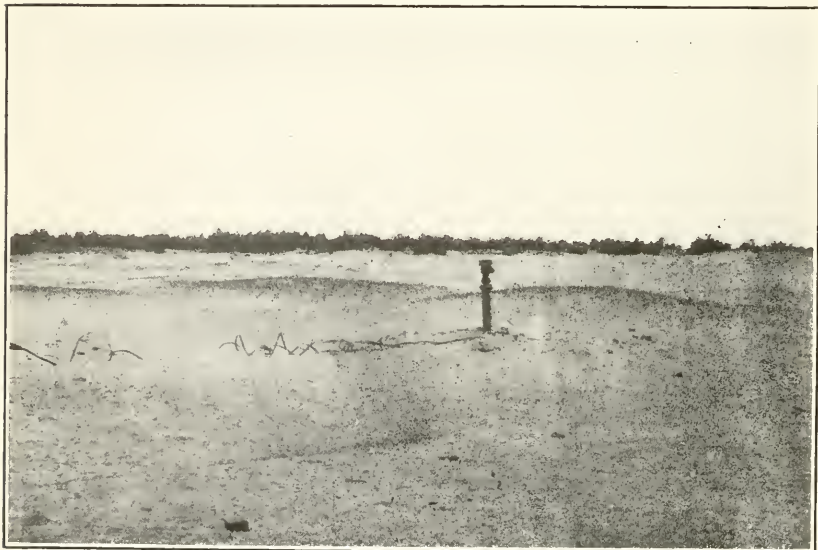
The sawmill, on which the prosperity of the town depended, ceased operations about five years ago.



F-27175A

FIG. 1.—DESOLATION ON THE AU SABLE RIVER, MICH.

The sawdust heaps in the background mark the ruins of a former sawmill, while the rotting piles in the foreground are all that is left of the extensive wharves that formerly lined the river and lake front.



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FIG. 2.—THESE DRIFTING SAND DUNES WERE ONCE A PART OF A PROSPEROUS MICHIGAN SAWMILL TOWN.

In the foreground note the hydrant, a part of the excellent watersystem formerly maintained by the town.

would have if used for the purpose approved by the classification would undoubtedly help to encourage its use for that purpose and to discourage speculation.

CONTINUOUS FOREST PRODUCTION.

When the lands that are to be devoted to the production of wood have been definitely marked off, preferably by some system of expert public classification, or, if that is not yet possible, by the judgment of the individual owner, destructive lumbering must be replaced by forest management. The first step in this direction is to insure adequate fire protection both of standing timber and cut-over lands. During recent years a great deal has been accomplished along this line through the combined efforts of the National and State Governments, some 40 fire protective associations, and many individual owners. With an average annual loss of at least \$10,000,000 from forest fires, however, much still remains to be done. Adequate fire protection is absolutely essential for the practice of forestry.

A second step is to keep the forest lands of the country continuously productive. A policy that allows immense areas of potentially productive forest lands to lie idle is not only short-sighted but exceedingly wasteful. If the 100 million acres of logged-off and burned-over forest lands on which, according to the estimate of the National Conservation Commission in 1908, little or no growth is now taking place, are capable of producing an annual return of \$1 an acre, by allowing them to lie idle we are practically throwing away each year \$100,000,000. Probably an equal amount is being lost each year through failure to secure the greatest possible growth on the remaining forest lands of the country. Even a nation so richly blessed with natural resources as the United States can ill afford such prodigality.

To reforest by artificial means the devastated areas is a task of enormous magnitude and in its entirety of almost prohibitive expense. Even if planting can be done successfully at an average cost of from \$5 to \$10 per acre, it will involve an outlay of several hundred million dollars. From this outlay, moreover, no return can be received for many decades. If compound interest is charged against it, the original investment will have doubled over and over again before the crop can be harvested. This means that there are very definite limits to which artificial reforestation can be conducted profitably, particularly by the private owner. Forestry that starts with the bare land is at best an expensive undertaking, and from a purely financial standpoint has very distinct limitations. If forestry is not to be practiced until the land has been denuded, we shall have but little of it for many years. Planting will be necessary in some cases, but it will not solve the whole problem or any great part of it.

A much better way to keep forest land productive is to start before the trees are removed. Steps should be taken to put the forest in better condition, and in this way to increase its productive capacity. Above all, however, every precaution should be taken to see that when the original stand is removed, adequate provision is made for a new crop to take its place. Forestry that starts while the trees are still on the ground is neither so difficult nor so costly a business as one that involves reclamation of denuded land. Ordinarily the new crop can be started at little expense by natural reproduction from the trees in the original stand. Even in those comparatively rare cases where planting must be resorted to, the burden is not so great as in the planting of land that has been denuded and abandoned, since the land is not so overgrown by weeds and brush and since only partial planting is usually necessary.

Starting the practice of silviculture before the land is denuded is also a prerequisite to the third step necessary to replace timber "mining" by forestry. This step consists in regulating the cutting of the timber on any given unit so that the same amount of material can be removed year after year; or, in other words, of utilizing the forest only as fast as it grows. It is perfectly possible for any capable forester to do this. The fact that timber is a crop that requires many years to mature is no reason why an approximately equal annual yield should not be obtained from forest land as well as from farm land. The only difference is that in the case of the timber the crop can not be removed from the same spot every year. Instead, the unit under forest management must be sufficiently large so that it can be divided into the same number of parts as there are years in the period required for the wood crop to reach maturity. One of these parts can then be cut each year, and a new forest started on it and allowed to grow until all the other parts have been cut, when it will again be ready for cutting. This process, of course, can be kept up indefinitely, and a permanent forest community established for the utilization of the annual cut. .

Where the forest is composed of trees of different ages, so that clear cutting of any given area is not practicable, the general principles for securing the same yield year after year still hold, although their practical application is not so simple. In this case, scattered trees are selected for cutting. This means that the cutting must cover a larger area each year and that partial cuttings on the same area must be made more often than where the trees are all of approximately the same age.

The size of the area that is necessary to provide a sufficient annual cut of timber to be profitable will naturally vary more or less in different parts of the country, according to the rate of growth, market con-

ditions, transportation facilities, and similar factors. Many forest regions, however, now have enough timber and are sufficiently developed economically so that a sustained annual yield large enough to warrant lumbering operations can be obtained within easy working distance of a permanent center: and this will become more and more true, both for these and other regions, as settlement and development of the country proceed. Even where for one reason or another it may not be feasible to continue lumbering operations indefinitely from the same center, it is entirely possible to apply the same general principle. The only difference is that there would be temporary subcenters, which would be moved from place to place at infrequent intervals, but which would nevertheless support a permanent population and would always remain in the same general region. The essential point is to maintain a balance between the annual cut and the annual growth on any given unit, which preferably should be as small as economic conditions make practicable, and to have a definite and comprehensive plan for the utilization of this cut.

If in the actual handling of our forest resources this ideal has been conspicuous by its absence, the blame may be laid upon economic conditions that have hitherto prevailed. The system of unregulated private ownership, the vast bodies of mature timber ready for cutting, the pressure of unrestricted competition, and the fact that lumbering has been a pioneer industry, which operated chiefly in regions of comparatively poor economic development, all conspired to make it unprofitable, and therefore impracticable, to handle the forests on a permanent basis. The time now has come, however, when this is no longer true. Conditions to-day are radically different in nearly every respect from those which heretofore have imparted to the industry its temporary character. It is now possible to practice the kind of forest management that will make the industry permanent and self-supporting.

Handling the forest lands of the country on the basis of sustained yield by no means necessarily involves decreased returns from the business. On the contrary, it may prove even more profitable. When timber "mining" is practiced the only profit that can ordinarily accrue to the timber owner is through a speculative rise in the value of his stumpage. This increase in value must be sufficient to meet not only the usual carrying charges but also a depletion charge for the forest capital destroyed. Assuming that the present stand of timber under private ownership is 2,200 billion board feet and that at the present rate of cutting all this will be removed in 55 years, the depletion charge against the industry is nearly 2 per cent. Until recently stumpage values have risen rapidly enough to met both this depletion

charge and carrying charges, and at the same time to yield a satisfactory return on the investment. With stumpage prices at their present level, however, and rising only comparatively slowly, it is doubtful whether this will continue to be true—certainly not to the extent that it has been in the past.

When forestry is practiced, however, the timber owner not only profits from any rise in stumpage value that may occur, but by keeping his forest continuously productive he avoids any depletion charge and provides a young, growing stand to meet carrying charges and to yield a return on the investment. To illustrate by a single example, an overmature stand of Douglas fir may produce a net growth of from 0 to 50, or at most 100, board feet per acre per year, while a young, well-stocked stand of the same species may yield approximately 800 board feet per acre per year up to 100 years of age. This means that on every acre that is cut over and reproduced to young growth, the annual wood production is at least eight times as great as it was before. As the cutting proceeds the amount of young growth increases steadily, until finally the virgin timber is replaced entirely by growing trees of all ages from one year to maturity. These have an annual productive capacity 700 per cent greater than that of the original stand and are therefore more capable of paying their own way and of yielding a permanent return on the investment. The establishment of the new crop will, of course, ordinarily cost something; but if this is done by means of natural reproduction at the time the original stand is removed, the expense need not be great. The time has now come when the practice of forestry will benefit not only the community, but also the industry itself.

STABILITY OF POLICY.

Stability of policy is vital to the practice of forestry. The production of timber is a long-time process, and as such demands foresight and continuity of management. Carefully prepared plans extending many decades into the future must be worked out in order to make it possible to secure the same yield year after year from any given forest. Plans for different forests will naturally vary more or less, according to the character of the forest, economic conditions, and the wishes of the owners, but all must have the common characteristic of assuming that the general policy on which they are based will be adhered to. Natural causes, such as fire, wind, insects, and fungi, will ordinarily interfere seriously enough with the carrying out of any plan without subjecting it to the additional handicap of a vacillating policy. From the standpoint of the technical forester a constantly shifting policy is almost as fatal to the practice of forestry as no policy at all.

From a financial standpoint also, stability of policy is necessary in order to make timber production a profitable business. Like other long-time investments, forestry can not be expected to yield a high rate of interest. In most parts of the country it will not return a profit greater than 5 per cent. This points directly to the necessity for cheap money, which is to be had only in businesses firmly established on a sound and stable foundation. Up to this time the lumber industry has subsisted chiefly on speculative capital, which has seldom cost less than 6 per cent and usually more. Whether this was necessary in the early development of the industry is perhaps debatable, but it is also immaterial so far as present conditions are concerned. The important point is that a stage has now been reached where the industry can not continue to yield the speculative returns that it has in the past. Carrying charges in most parts of the country have now become so heavy that they are mounting up as fast or faster than stumpage is increasing in value. In other words, timber holding, pure and simple, is becoming unremunerative and must be supplemented by timber growing. But timber growing, from the very nature of the product, will not pay a high rate of interest, and the only way in which money can be obtained at low rates is by putting the business on a stable, nonspeculative basis.

There is no good reason why forestry, the business of continuous timber production, should not be put on such a basis. We already know enough about our forest trees to keep the land productive and to make the annual cut approximately equal to the annual growth. Stumpage prices are now sufficiently high to yield a moderate return if forest management is started before the trees are cut off. European experience has proved that with adequate care and protection the business of timber growing is one of the safest and most conservative forms of investment.

How to secure a clear-cut and stable forest policy is one of the chief problems to be solved in placing the management of our forests on a sound and permanent basis. Taking the country as a whole, private ownership has so far failed to do this. It is true that in many parts of the Northeast the prevailing uneven-aged forest, limited fire hazard, and favorable markets have resulted in the practice of a crude sort of forestry. Because of the character of the forest, clear cutting has been the exception rather than the rule, and forest production has been more nearly continuous here than in other parts of the country. But these good effects, like the bad effects elsewhere, have been mainly accidental and not the result of any far-sighted policy. With comparatively few exceptions private ownership so far has been content to let the future take care of itself. Nevertheless, it is possible that under the changed conditions that now exist many private owners may find it to their advantage to adopt a stable

policy, which would enable them to really practice forestry. Every effort should be made to bring about such a desirable result, since it appears certain that for many years at least the bulk of forest lands of the country will remain in private hands.

If the adoption of a stable forest policy is to become at all general among private owners, it will involve a radical change in the character of much of the capital now invested in timberlands. The business of growing timber under forestry principles will not attract speculative capital. Timber stocks and bonds, however, if properly secured by land and timber under forest management, may prove a safe and profitable investment for saving banks, insurance companies, and individuals who are looking for security rather than for high returns. Any change necessary to make such investments available must necessarily involve the elimination of the speculative element in timber holding. Probably this will take place gradually and will be accompanied by more or less liquidation, according to market conditions during the transition period. It has also been suggested that some widespread organization among timber owners, under restrictions to safeguard the public interests, would go far toward bringing about the desired stability.

PUBLIC CONTROL AND OWNERSHIP.

Increased public participation in the management of timberlands will be another powerful factor in bringing about the practice of forestry and in doing away with the evils that so far have accompanied uncontrolled private ownership. For one thing, it seems probable that in time the United States will follow the lead of many other countries in exercising public control over privately owned "protection forests," that is, mountain forests which help to protect the land from erosion and to insure uniform stream flow. This function of the forest is so important to the welfare of the entire community that the control of such areas has generally been looked upon as a proper function of the Government. Control is usually exercised by requiring absolute fire protection and by regulating the cutting of the forest in such a way as to maintain the desired protection.

Public control may, in the not very distant future, also extend to many private forests which are managed primarily for timber production and in which the protective feature is of little or no importance. This control may affect both the technical and the business end of forest administration. If forest owners should be permitted to organize on any considerable scale as a means of assisting them to practice forestry, it is certain that the public would want a deciding voice in matters affecting its own interests. It would, for example, wish to supervise the financing, and particularly to exercise absolute control over any steps looking toward arbitrary limitation of cut or

fixation of prices. Whether this would involve public control over certain technical aspects of forest production would depend altogether on the need for such action. If private owners, either individually or collectively, prove incapable of practicing forestry, the public, for its own protection, must take a hand in the business. This would in all probability involve the participation of technical foresters, employed by the public, in the preparation of detailed forest working plans covering fire protection, methods of cutting, amount of material to be removed each year, and similar matters.

Public influence in the handling of the forest lands of the country will also make itself felt through the extension of public ownership. This is a logical and inevitable development. The public, whether represented by the Federal or State Governments, is in many respects in a much better position to practice forestry than the average individual or corporation. It does not have to secure such a high rate of interest on its investment, it is not under the same pressure to secure the greatest possible returns immediately, it is not affected by speculation, and, above all, it is concerned fully as much with the future as with the present. The State exists primarily for the purpose of promoting the development and increasing the well-being of its entire population, both present and future. One of its main functions is to provide for its own prosperous perpetuity. Forestry, which necessarily looks to the future as well as to the present, is a peculiarly appropriate function to be assumed by the Government.

Considerable advance has already been made in this direction. In 1872, when the Yellowstone Park was established, the first step was taken to retain public control over even a small portion of the forested area of the country. The most important advance in this direction came in 1891, when Congress authorized the President to set aside forest reserves—now called National Forests—from the unappropriated public domain. Since then a steadily increasing amount of forest land has been brought under management for the benefit of the public. To-day some 136,000,000 acres in the United States proper are held by the Federal Government as National Forests, and some $3\frac{1}{2}$ million acres by 13 different States as State forests. With four-fifths of the timberland of the country still under private ownership, however, there is no danger of moving in this direction too rapidly. On the contrary, every effort should be made to increase both Federal and State holdings whenever and wherever possible.

Above all, title should be retained to all forest land now publicly owned. New York, in 1883, passed legislation prohibiting the further sale of land acquired through nonpayment of taxes. Since 1905 Pennsylvania has ceased to sell its public land for $26\frac{2}{3}$ cents an

acre, while at the same time buying back for forest-reserve purposes similar land, stripped of its timber, for \$3 or \$4 an acre. Michigan no longer disposes of its delinquent-tax lands for \$1 an acre, but holds such lands, when nonagricultural in character, for forest reserves. Similar action by all States would go far toward forming a substantial nucleus around which an adequate system of State forests could eventually be built up. The Federal Government should retain the forest lands that it already holds and should add to these, as opportunity permits, both by purchase and by exchange. The objection that such a policy will decrease local revenues by withdrawing lands from taxation can be readily met in two ways. The State can construct and maintain its fair share of community improvements, or it can contribute to the local communities on the basis of the acreage or value of such lands or the receipts from them; or both methods can be used, as is now done in the case of the National Forests.

As public ownership gradually increases and a larger and larger proportion of the forest lands of the country are managed for a sustained annual yield, this policy will undoubtedly have a marked influence in bringing about a more conservative and more permanent handling of forest lands still held by private owners and particularly by big corporations.

COMMUNITY BENEFITS.

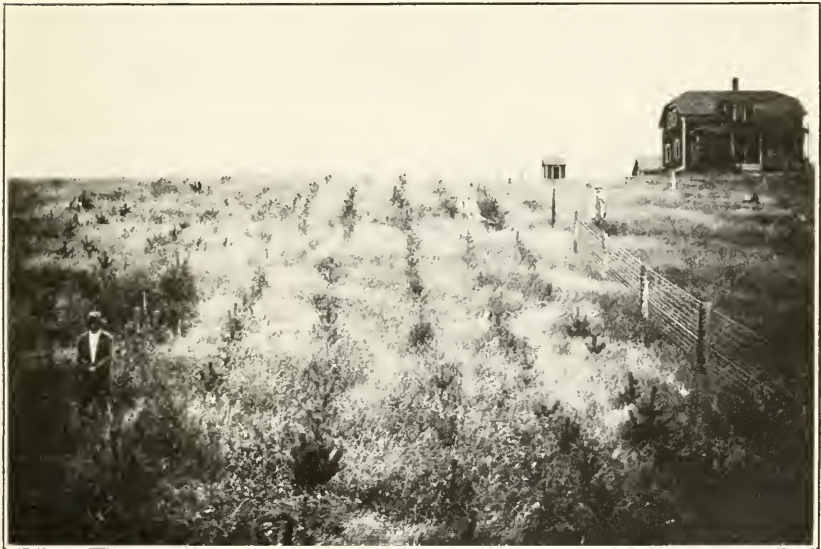
The practice of forestry on the forest lands of the country will obviously benefit the community in general by doing away with the harmful social and economic effects of timber "mining." When continuous forest production is secured on lands classified by experts as primarily valuable for that purpose, lumbering will no longer be a roving industry, leaving desolation and abandoned towns in its wake. Instead there will be a permanent population engaged in the care and utilization of the forest and its products. This forest community also will make profitable the cultivation of whatever farming land there is in the region and so help to support a permanent agricultural population.

Forestry thus will tend to check the present alarming drift from the country to the city, and will contribute materially toward building up a larger rural population. By furnishing opportunities for employment where none now exist, it will do its share to assist in solving the vexed problem of the unemployed. In Australia the undertaking of State forestry has in fact been strongly advocated as a considerable remedy for rural depopulation, unemployment, and pauperism. A well-managed forest requires much labor in protecting it from fire and other injuries, in nursery and planting work, in making thinnings, in constructing roads, trails, bridges, telephones, and other permanent improvements, and in cutting the timber and other products and getting them to the market, to say nothing of the



F-23778A

FIG. 1.—A BIT OF VIRGIN NORWAY PINE FOREST ON THE SHORE OF TROUT LAKE, WIS.
Thousands of acres formerly covered with stands of this sort are now desolate as a result of destructive lumbering and fires.



F-23773A

FIG. 2.—PLANTATION MADE BY THE STATE OF WISCONSIN ON CUT-OVER LAND ON
THE OUTSKIRTS OF THE TOWN OF STAR LAKE.

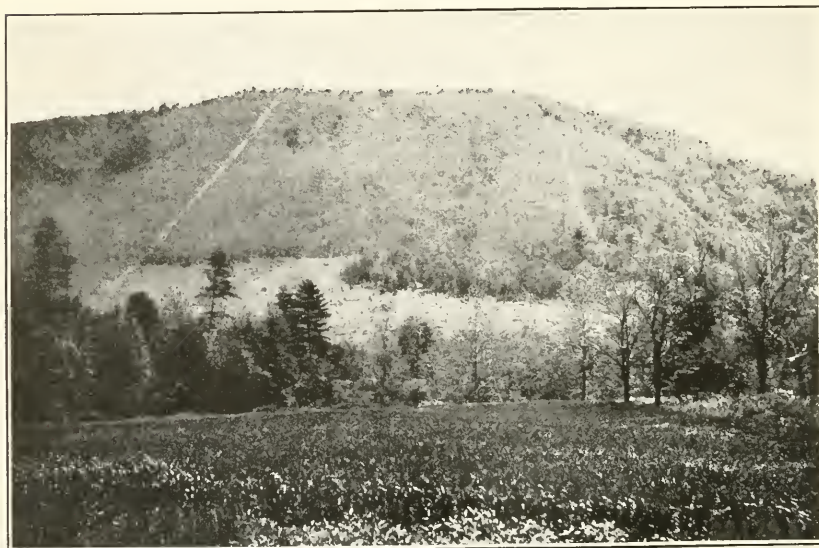
The building on the right is a State forest ranger station.



F-27158A

FIG. 1.—POOR FARM LAND MAY BE GOOD FOREST LAND.

This area in Roscommon County, Mich., formerly covered with a good stand of pine, was clear cut and an attempt made to farm it. It was soon abandoned, however, and reverted to the State for taxes. It is in the heart of one of the State Forest Reserves and is now being used for forest production, for which it is preeminently suited.



F-23129A

FIG. 2.—A CUT-OVER AREA, STRIPPED OF ITS TIMBER, BEING REFORESTED BY THE PENNSYLVANIA DEPARTMENT OF FORESTRY.

Two fire lines are shown in the picture, one on each side of the plantation.

subsequent manufacture of such products. In England and Australia it is estimated that forests give ten times as much average employment as sheep farms of the same size, without taking into account the population absorbed in attendant industries, which in many cases is said to amount to treble this figure.

The population supported by stable forest industries will also be of a higher type than the wandering, pioneer character of the lumber industry hitherto has made possible. Permanent homes and a normal family life, coupled with increased social and educational opportunities, will develop the more civilized virtues without destroying the courage, vigor, alertness, and physical prowess that always have been characteristic of the typical woodsman. The strength of the Nation comes primarily from the soil, and the welfare of the entire country is promoted by any industry that affords permanent employment for a large rural population of high type.

In addition to the stable communities of permanent inhabitants which the practice of forestry will make possible, the transient population that will be attracted to the region for sport or recreation must not be overlooked. Such visitors not only will gain health and inspiration from their visits but will add materially to the prosperity of the local communities. Hundreds of thousands of dollars are now spent every year by hunters, fishermen, tourists, and others in search of recreation. The scenic attractions of a region are a very substantial asset to the transportation companies, owners of hotels and other summer resorts, guides, and local settlers. They help materially to increase business and to promote the development of the community in general.

The maintenance of forest lands in a continuously productive condition will further benefit the individual and the community by assuring a local supply of wood. This will do away with the local shortages of timber which are now becoming pronounced in many regions once well forested and will thus obviate the necessity of paying high freight charges and to a certain extent middlemen's charges on material imported from considerable distances. The establishment of permanent settlements will also stabilize transportation facilities, which in turn will contribute to the development of the entire region. And finally the use of the land for the purpose to which it is best suited, under such public supervision as may be necessary, will to a large extent do away with the speculation and fraud which hitherto have so often accompanied forest destruction.

In a word, the practice of forestry on forests lands throughout the country would mean the building up of permanent, prosperous, forest communities which would contribute immeasurably to the development and welfare of the Nation.

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UNITED STATES DEPARTMENT OF AGRICULTURE
BULLETIN No. 639

Joint Contribution from the Bureau of Animal Industry, JOHN R. MOHLER, Chief
and the Bureau of Markets, CHARLES J. BRAND, Chief

Washington, D. C.



February 15, 1918

THE MARKET MILK BUSINESS OF
DETROIT, MICH., IN 1915

By

CLARENCE E. CLEMENT, Dairy Division, Bureau of Animal Industry
and GUSTAV P. WARBER, Bureau of Markets

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ECONOMIC PHASES OF THE MARKET MILK BUSINESS.

Preliminary studies by the Department of Agriculture have shown the existence of many uneconomical practices in the market milk business. These practices have been largely the result of the rapid changes that the business has undergone in recent years. Constantly increasing demands for market milk in the larger cities of this country have resulted in such a rapid increase in the business of "middlemen" or dealers that many fundamentally uneconomic marketing practices have developed and wasteful leaks have been allowed to occur daily. In short, efficiency systems have not kept pace with the growth and development of the business.

NOTE.—This bulletin should be of interest to milk dealers, city and State milk-inspection officials, consumers' leagues, producers' organizations, and students of the subject of market milk.

In the present study¹ is presented a general analysis of the market milk business as conducted in Detroit, Mich., during the year 1915, with a view of indicating some of the fundamental explanations of existing market conditions and milk marketing practices in the larger American cities. The cost of milk, wages, and many items of expense have increased greatly since the data were obtained, and for that reason no attempt has been made to show absolute cost and profit figures. Some cost analyses are presented, however, in a way that will point out fundamental tendencies not dependent upon transitory changes in prices and which help to explain some of the prevailing market practices.

The city of Detroit, Mich., was selected for the study primarily because in many respects milk marketing methods in that city are representative of those in other large cities of the United States. Since the pasteurization of market milk had been made compulsory by ordinance in Detroit three months before the investigations were begun, the selection of that city also permitted a study of the effects of compulsory pasteurization upon the number of dealers engaged in the business and upon the methods of handling and distributing milk.

MARKET DEMANDS AND SOURCES OF SUPPLY.

The average quantity of market milk consumed daily in Detroit during August, 1915, was approximately 47,569 gallons, and of market cream 5,953 gallons. Based upon an estimated population of 600,000 this would provide approximately 0.63 of a pint of milk and 0.08 of a pint of cream per capita daily. The consumption is not uniform throughout the year, however. The shipments of milk during May and June were the highest of the year, but the receipts were in excess of the city consumption during those months.

According to the records of one of the largest dealers, the market demand for milk in per cent of the yearly consumption is shown below by seasons:

	Per cent of total.
Spring -----	26.7
Summer-----	30.2
Fall-----	20.9
Winter-----	22.2
	100

It will be noted that the consumption during the summer months was one-half higher than during the fall months.

¹ Most of the data upon which this study is based were collected during September and October, 1915. Figures of total quantities of milk handled and general information concerning the nature of the business of all the dealers were obtained from the records of transportation companies and the files of the milk-inspection department of the Detroit board of health. The cost analyses were based upon the records of certain typical dealers.

Figure 1 shows the area from which the supply of milk and cream was obtained, each dot representing one 10-gallon can of milk or cream. The small squares show the location of country milk stations where milk was collected, weighed, and cooled before it was transported to the city pasteurizing and bottling plants. The figure

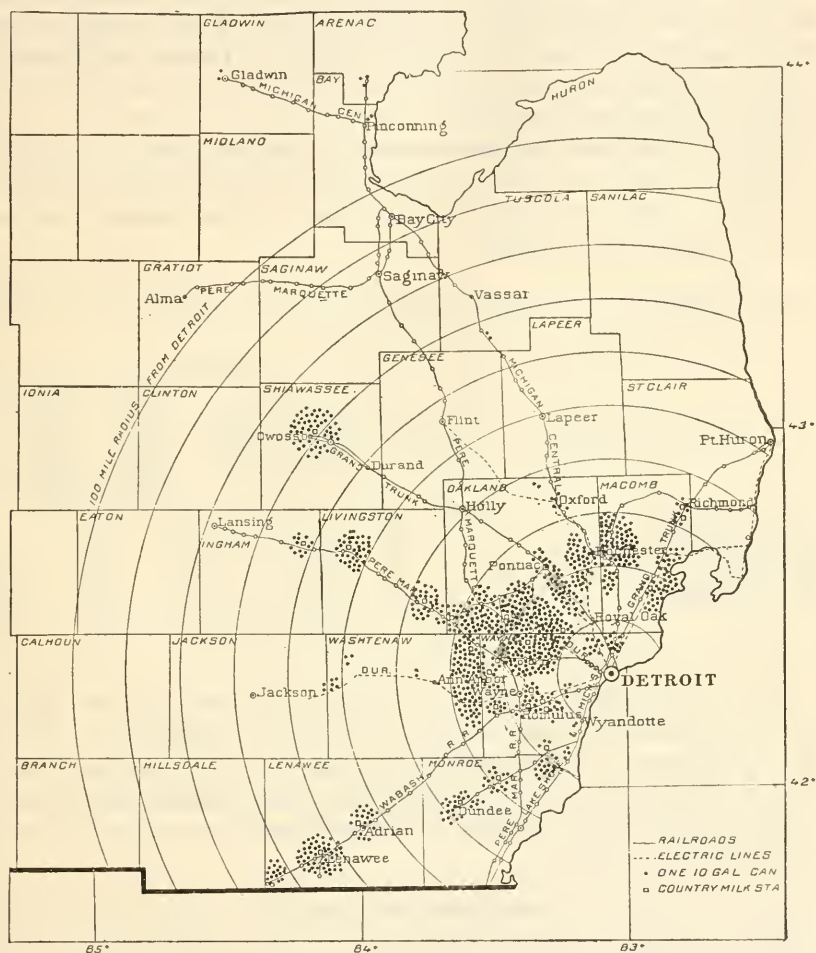


FIG. 1.—Sources of milk and cream supply of Detroit, and the steam and electric railways over which most of it is transported to the city.

shows that the greater part of Detroit's supply of milk was produced within 30 miles of the center of the city. Some shipments of cream originated in zones 100 miles distant or more. Because of the stringent regulations of the board of health in regard to city dairies, the quantity of milk produced within the city was negligible.

BUYING MILK FROM FARMERS.

Figure 1 also shows the necessity for middlemen to handle and distribute the greater part of the city's supply. Farmers living more than 6 or 8 miles from town generally considered it impracticable to deliver their milk to the consumers. The quantity of milk produced on the average farm in that territory is not sufficient for economical market distribution by the farmer. To realize the greatest labor income he usually deems it advisable to devote his entire attention to farming operations.

In Table I the milk dealers operating in Detroit during the month of August, 1915, are grouped according to the quantity of milk handled as well as the quantities supplied to other dealers who did not buy from farmers direct.

TABLE I.—*Milk dealers who bought from farmers during August, 1915, according to volume of business.*

Gallons handled daily.	Number of plants.	Number of gallons handled daily.	Per cent of total city supply.	Number of gallons sold to dealers not buying from farmers.	Per cent of supply sold to dealers not buying from farmers.
Less than 150 gallons.....	6	336	0.63	.....	.....
150 to 250 gallons.....	35	5,594	10.46	569	10.17
251 to 500 gallons.....	11	3,960	7.41	915	23.11
501 to 1,000 gallons.....	5	3,365	6.29	1,195	35.51
More than 1,000 gallons.....	11	40,205	75.21	2,165	5.38
Total.....	68	53,460	100.00	4,844	9.06

Sixty-eight dealers in Detroit bought milk from farmers direct and had plants for preparing it for market distribution, either through their own or other dealers' equipment. The grouping of the dealers in accordance with average quantities of milk handled daily shows that the greater portion of the business was handled by comparatively few dealers.

PRICES PAID TO FARMERS.

Most of the larger dealers paid for milk on a butterfat basis, while the majority of smaller ones bought their milk by weight or measure without allowing premiums or making deductions based on butterfat content, sediment test, bacterial content, or the score of the dairy farm on which it was produced. The larger companies usually based their monthly price quotations to farmers upon a butterfat test of 3.5 per cent. For each one-tenth of 1 per cent butterfat the milk tested below 3.5 per cent the price was reduced 2 cents a hun-

dredweight. For milk testing more than 3.7 per cent a premium of 2 cents for each one-tenth of 1 per cent butterfat was paid. When compared upon a common basis the prices actually paid by the various dealers were found to vary considerably.

Figure 2 shows the average prices (f. o. b. Detroit) paid by milk dealers handling different quantities of milk during 1915, as well as the rather wide seasonal variations in prices paid to farmers. A fundamental reason for these variations is that at certain seasons the quantity of milk supplied by farmers is either above or below the city demands, because farmers generally can not regulate their daily and seasonal production in accordance with the varying demands of city consumers. As farmers generally did not utilize the

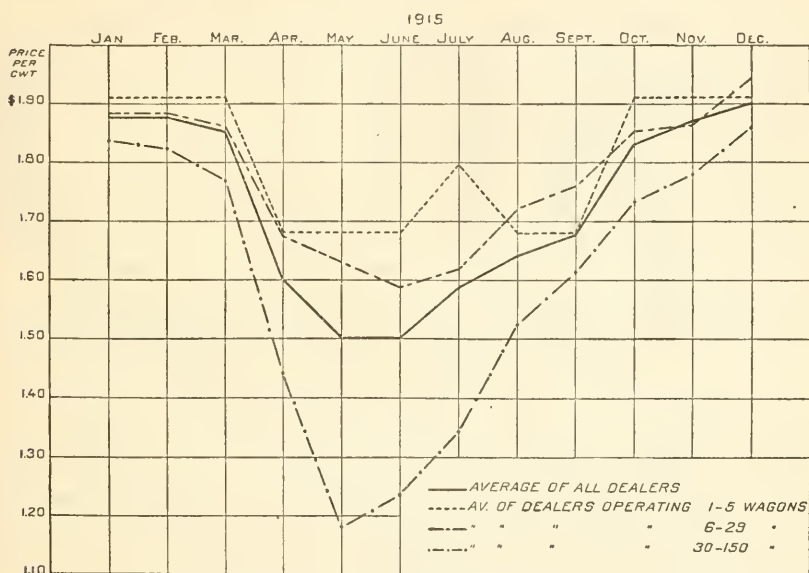


FIG. 2.—Average prices paid farmers by all milk dealers, grouped according to number of delivery wagons operated by each.

milk produced in excess of the demands for market milk, the dealers bought all the milk. That necessitated the manufacture of cheese, butter, or condensed milk, which seldom yield as much as market milk. Some of the dealers who had no facilities for the economical disposal of skim milk actually dumped it into the sewers.

The prices paid by the larger dealers fluctuated more than those paid by the smaller ones. The latter also usually paid the highest prices for their milk, which is explained in part by the fact that the former obtained their supplies from localities farther from the city, where competition for market milk was not so keen, and where increased costs of transportation tended to reduce the prices paid to the farmer as is shown in Table II.

TABLE II.—*Transportation costs in relation to farmers' prices.*

Shipping station number.	Freight or trucking cost per 10-gallon can to Detroit.	Farm prices per 10-gallon can to Detroit.	Cost to dealer f. o. b. Detroit.	Shipping station number.	Freight or trucking cost per 10-gallon can to Detroit.	Farm prices per 10-gallon can to Detroit.	Cost to dealer f. o. b. Detroit.
1.....	\$0.15	\$1.53	\$1.68	7.....	\$0.20	\$1.53	\$1.73
2.....	.15	1.49	1.64	8.....	.22	1.42	1.64
3.....	.15	1.53	1.68	9.....	.23	1.42	1.65
4.....	.175	1.53	1.705	10.....	.24	1.36	1.60
5.....	.175	1.42	1.595	11.....	.28	1.28	1.56
6.....	.175	1.53	1.705	12.....	.30	1.23	1.53

This table shows that although there was a tendency to pay less for milk or cream as the distance and cost of transportation increased,

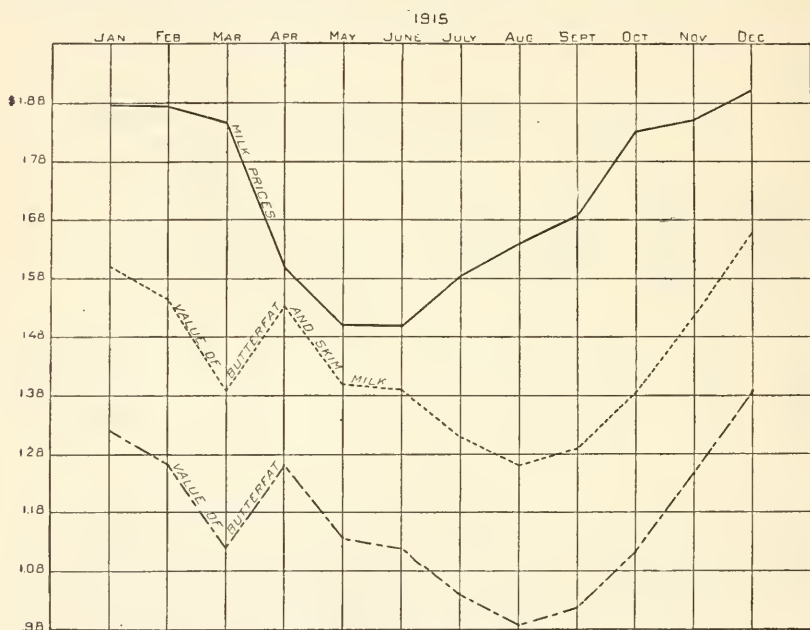


FIG. 3.—Comparisons of average prices paid by Detroit milk dealers with value of the milk if the cream had been delivered to local creameries and the skim milk fed to live stock on the farm.

the prices actually paid to farmers depended upon other factors as well. In territory where farmers could sell to local creameries or cheese factories the prices for milk were influenced by the prevailing market prices of butter and cheese.

Table III and figure 3 show the relation between average prices paid by the Detroit milk dealers in 1915 and the average monthly wholesale butter quotations in Chicago. The table and figure also present the estimated possible returns which farmers might have obtained if they had marketed their cream at local cooperative creameries, whose product is generally sold in accordance with Chicago quotations. The estimated returns are based upon the assumption

that skim milk has a value of 30 cents a hundredweight for feeding purposes. Ninety pounds of skim milk were allowed for each 100 of whole milk.

TABLE III.—Average prices, by months, paid for 100 pounds of 3.7 per cent milk by all classes of milk dealers in Detroit; also estimated average returns for butterfat delivered to a local creamery.

Months.	Average prices paid per hundredweight of milk.				Average prices per pound for butter. ¹	Possible returns from creameries. ²	
	Small dealers.	Medium dealers.	Large dealers.	All dealers.		For butterfat per hundred-weight of milk.	For butterfat plus 27 cents for 90 pounds of skim milk.
					<i>Cents.</i>		
January.....	\$1.91	\$1.884	\$1.836	\$1.876	31.7	\$1.321	\$1.591
February.....	1.91	1.884	1.823	1.872	30.437	1.264	1.534
March.....	1.91	1.864	1.77	1.848	27.204	1.119	1.389
April.....	1.68	1.678	1.442	1.60	30.375	1.262	1.532
May.....	1.68	1.63	1.180	1.73	27.46	1.130	1.400
June.....	1.68	1.588	1.235	1.501	27.175	1.118	1.388
July.....	1.795	1.618	1.343	1.585	25.5	1.042	1.312
August.....	1.68	1.720	1.523	1.641	24.293	.987	1.257
September.....	1.68	1.760	1.616	1.685	25.016	1.020	1.290
October.....	1.91	1.851	1.733	1.831	27.156	1.117	1.387
November.....	1.91	1.864	1.780	1.851	30.025	1.246	1.516
December.....	1.91	1.942	1.860	1.904	33.208	1.390	1.660
Total average.....	1.805	1.774	1.595	1.744	28.295	1.168	1.438

¹ Butter prices are the monthly averages of Chicago quotations on the basis of which most of the creameries of that section sell their butter.

² These returns are computed on basis of 3.7 per cent butterfat in milk and on the basis of 22 per cent overrun in butter manufacture, and a cost of 2.42 cents a pound for manufacture.

The table and figure also show that there was no constant relation between the monthly average wholesale prices of butter in the Chicago market and monthly average prices paid for milk by Detroit dealers. Farmers in that territory generally received higher prices for milk than they would have obtained if they had delivered the cream to local creameries for the manufacture of butter and had fed the skim milk on the farm. Farmers have found that it requires great care and expense to produce and deliver daily a good grade of market milk, whereas three deliveries a week are usually sufficient for buttermaking purposes.

At certain seasons of the year, however, some of the dealers bought milk for less than it would have yielded the farmers if it had been utilized in the manufacture of butter and the feeding of live stock, which may be explained by the fact that the companies which own and control country milk stations may obtain virtual buying monopolies in certain localities. The prices paid to farmers for milk usually depend upon existing competition. Small dealers who do not own or control country milk stations are generally unable to buy milk in distant areas. In the absence of market information and active competition of manufacturing plants it may also be possible to buy market milk for less than it would yield for manufacturing purposes.

COLLECTING AND HANDLING MILK IN THE COUNTRY.

The milk dealers in Detroit obtained their supplies of milk and cream either from individual farmers direct or through country receiving and cooling stations. The smaller dealers usually gathered their supplies near by, mainly because they could not afford the investments in country receiving stations, through which the larger dealers collect the most of their supplies from the more distant areas of production. (See fig. 1 and Table IV.) Most of the supply which came from neighboring territory was gathered from farms by means of wagons or motor trucks owned by the city dealers. Considerable quantities of both milk and cream were also shipped directly to the city by farmers who lived near railway stations or crossroads milk-shipping platforms. There was keen competition for all supplies of milk or cream directly accessible to the city.

In order to obtain milk from many farmers who lived too far from railroad stations or shipping platforms to make direct shipping practicable, it was necessary to establish facilities for collecting milk enough at one place to permit more economical transportation to the city plant. Farmers generally do not consider it advisable to make daily trips for delivering milk when the shipping station is more than 5 miles away. An additional advantage of the country receiving and cooling stations was that milk could be cooled to the proper temperature before it was shipped to the city; furthermore, the inspection and buying of milk according to quality was expedited. When a farmer watches the sampling of his milk and the making of sediment and butterfat tests he understands better the justice of paying different prices for different grades of milk. It often happens that dairy products can be manufactured more economically in the country than in the city, and for that reason the larger milk companies frequently operate country milk plants, where the surplus not required for market milk trade may be converted into other products.

Table IV shows the quantities of market milk obtained through country stations during June, 1915.

TABLE IV.—*Milk obtained through country stations during June, 1915.*

Number of wagons operated by dealers.	Number of dealers.	Number of stations from which milk was received.	Number of gallons received monthly.		Per cent of total shipped through stations.
			From stations.	From farms.	
1 to 5.....	55	.....	.....	291,600	.....
6 to 29.....	11	22	356,224	239,005	59.8
30 to 150.....	2	51	1,002,606	153,257	86.7
Total.....	68	73	1,358,830	683,862	66.5

The total number of gallons handled by different groups of dealers, as shown in Tables I and II, does not correspond to the total shown in Table IV, because large quantities of milk were bought from farmers by those dealers and not used for market milk purposes but manufactured into butter, cheese, condensed milk, powdered milk, and casein.

The larger companies obtained the greater part of their supply through the country milk stations or "collecting depots," which they usually owned. A few of the country stations were owned either by farmers' cooperative associations or by individual farmers whose dairy houses were equipped to handle truck loads of milk produced on neighboring farms. (See Pl. I, fig. 1.)

The typical milk-receiving station consisted of a wooden-framed building equipped with a small boiler, apparatus for washing and sterilizing milk utensils, scales for weighing milk, and a tank for holding the cans of milk in ice water until time to ship to the city. During the winter natural ice was usually stored in an adjoining building for use in the summer. Stations which skimmed or utilized surplus milk at certain seasons had additional and more expensive equipment, such as receiving tanks, mixing vats, cheese vats, separators, churns, pasteurizers, coolers, and equipment for condensing milk. (See Pl. I, fig. 2.)

Table V shows the relation of the amounts invested in 16 country milk stations to the number of gallons handled daily.

TABLE V.—*Relation of investment in country stations to gallons of milk handled daily during June, 1915.*

Station number.	Gallons of milk handled daily.		Investment in buildings and equipment.	Investment per gallon handled daily.
	Cooled.	Skimmed.		
1.....	77	.....	\$380.00	\$4.94
2.....	124	.....	818.00	6.60
3.....	172	.....	440.00	2.59
4.....	226	.....	876.00	3.88
5.....	317	.....	1,325.00	4.18
6.....	382	.....	1,675.00	4.39
7.....	447	.....	609.00	1.36
8.....	465	.....	1,325.00	2.85
9.....	779	.....	3,450.00	4.43
10.....	842	.....	4,553.00	5.41
11.....	1,009	.....	2,253.00	2.23
12.....	760	720	1,800.00	1.22
13.....	738	830	1,952.00	1.24
14.....	1,907	.....	4,752.00	2.49
15.....	1,404	1,155	2,053.00	.80
16.....	2,662	.....	5,745.00	2.16
Average.....	769	.....	2,125.00	3.17

The investment in the stations does not bear a direct relation to the quantity of milk shipped. Some of the stations were creameries or cheese factories which had been converted into receiving stations,

and neither the buildings nor the equipment had been specially provided for the milk-station business. In some cases the investment was larger than necessary when neither milk skimming nor dairy manufacturing was done. Table VI shows the daily expense of maintaining and operating the stations included in Table V.

TABLE VI.—Average daily expense of collecting and handling milk at country stations during June, 1915.

Station number.	Gallons handled daily.		Depreciation and interest on building and equipment.	Labor and supplies in plant.	Route costs of collecting milk.	Total station expenses.	Average cost per gallon handled.
	Cooled.	Skimmed.					
1.....	77	.....	\$0.17	\$0.90	.....	\$1.07	\$0.013
2.....	124	.....	.36	.70	.....	1.06	.008
3.....	172	.....	.20	.90	.....	1.10	.006
4.....	226	.....	.39	1.23	.....	1.62	.007
5.....	317	.....	.59	1.60	.....	2.19	.006
6.....	382	.....	.74	1.60	.....	2.34	.006
7.....	447	.....	.27	.97	.....	1.24	.002
8.....	465	.....	.59	2.47	.....	3.06	.006
9.....	779	.....	1.53	3.53	\$4.50	9.56	.012
10.....	842	.....	2.02	2.87	3.20	8.09	.009
11.....	1,009	.....	1.00	2.70	.....	3.70	.003
12.....	760	720	.80	2.87	13.87	17.54	.011
13.....	738	830	.87	3.53	10.08	14.48	.009
14.....	1,907	.....	2.11	3.97	4.05	10.13	.005
15.....	1,404	1,155	.91	3.90	.....	4.81	.001
16.....	2,662	.....	2.55	5.63	.....	8.18	.003
Average....	769	901	.94	2.48	7.14	5.64	.007

The average cost per gallon of milk for operating the stations varied greatly. When surplus quantities of milk and cream were manufactured into butter, cheese, etc., at country stations, the operating expenses were increased. Some stations, however, show higher operating expenses than others, because the cost of collecting the milk in the country was included in the statement of expenses.

COST OF COLLECTING MILK AT COUNTRY STATIONS.

The prices paid for milk were usually based upon its delivery f. o. b. the city plant. The cost of transportation, therefore, must be deducted in order to obtain the farmers' actual net returns. In order to get sufficiently large supplies at some stations the milk dealers had established "milk-collecting routes" for collecting milk and cream from farmers living as far away as 10 miles. At 19 country milk stations there were 843 patrons, of whom 503 had their milk delivered by paid route men.

The farmers' share of the costs of country collecting averaged 12½ cents a hundredweight and varied from 8 to 18 cents a 10-gallon can. In addition to the amount paid by the farmer, the milk dealers were sometimes obliged to pay the route men a bonus of from \$2 to \$3 a

trip, depending upon the length of the route. The varying costs on different routes at a single country station for country collecting are shown in Table VII.

TABLE VII.—*Cost of collecting milk, by routes, June, 1915.*

Number of route.	Number of patrons.	Pounds of milk.	Paid by farmers.	Paid by company.	Average total cost per hundred-weight.
1.....	6	29, 113	\$29. 11	-----	\$0. 100
2.....	14	41, 380	60. 51	\$75. 00	. 327
3.....	11	32, 402	32. 40	32. 40	. 199
4.....	13	35, 815	46. 18	75. 00	. 338
5.....	14	30, 242	45. 96	87. 50	. 441
6.....	20	67, 911	117. 72	117. 72	. 346
7.....	23	60, 732	91. 09	91. 09	. 299
8.....	16	48, 544	76. 76	76. 76	. 316
9.....	11	43, 153	43. 16	60. 00	. 239
10.....	4	11, 629	14. 09	14. 09	. 242

TRANSPORTATION OF MILK TO THE CITY.

A large portion of the milk produced within a radius of 20 miles of Detroit was "trucked" to the city plants either by team or by automobile, but the greater part of the total monthly receipts of milk and cream was shipped on either steam or electric railroads. Table VIII gives the total quantities of milk and cream (both sweet and sour) which were received in Detroit during the month of July, 1915.

TABLE VIII.—*Quantities of milk received in Detroit during July, 1915.*

Means of transportation.	Gallons.	Per cent of total.
Steam roads.....	630, 990	41. 8
Electric roads.....	637, 860	42. 3
Teams or automobile trucks.....	239, 780	15. 9
Total.....	1, 508, 630	100. 0

The electric lines provided milk cars with side-extension decks which permitted two tiers of cans, while the shipments on steam roads were handled in ordinary baggage cars. The farmers delivered their milk to the shipping stations early in the morning, and most of it arrived in Detroit by noon of the same day. Very little milk was in transit more than 4 hours. In warm weather it was "precooled" either on the farm or at the country milk stations before it was shipped, as refrigeration was not provided (except in one instance) by the roads.

Table IX gives a comparison of the milk and cream tariffs (effective August 1, 1915) for shipments of 10-gallon cans of milk or cream into Detroit on the various transportation lines.

TABLE IX.—*Comparison of transportation rates on electric and steam railways in the Detroit market milk territory during the year 1915.*

Rates per 10-gallon can.	Distance, in miles, for which rates apply.			
	Detroit United Railways (electric).	Pere Marquette Railroad.	Michigan Central Railroad.	Grand Trunk Railroad.
\$0.15	1-30	1-25	1-25	1-17
.20	.....	1-25	1-25	18-55
.21	.....	26-30	26-30	.....
.22	31-35	31-35	31-35	.....
.23	36-40	36-40	36-40	.....
.24	41-45	41-45	41-45	.....
.25	46-50	46-50	46-50	56-75
.26	51-60	51-60	51-60	.....
.27	61-70	61-70	61-70	.....
.28	71-80	71-80	71-80	.....
.29	81-90	81-90	81-90	.....
.30	91-100	91-100	91-100	76-100

In order to transport bottled milk from a milk-bottling plant about 30 miles from Detroit, an insulated milk car on the electric line was equipped with brine pipes by means of which the car could be refrigerated. Refrigeration was obtained by connecting the brine coils under the ceiling of the car with the brine tanks in the country milk plant, and while the car was being loaded the cold brine was pumped through the coils, thus cooling or refrigerating the car. Milk containers made of fiber were used in place of glass bottles. (See Pl. II, fig. 1.)

The concrete roads which extend into the country surrounding Detroit make it possible to haul a considerable portion of the milk direct from the farms or country milk stations to the city milk plants. Both horse-drawn and motor trucks are used for the purpose, although, because of their greater speed, the latter are superseding the former, especially on long hauls.

From a number of country milk stations milk was trucked to the city plants by the same men who had charge of the receiving and cooling operations. The actual amounts paid by milk dealers to persons who hauled milk from country stations to the city, by either motor or horse truck, were ascertained at several stations. Table X presents a comparison of the trucking costs with the transportation rates for equal distances by rail.

TABLE X.—*Costs of trucking milk compared with rail transportation rates.*

Number of station.	Average number of cans hauled daily.	Distance hauled (miles).	Comparative transportation costs per can.		
			Trucks.	Steam roads.	Electric roads.
1.....	30.7	12	\$0.15	\$0.20	\$0.15
2.....	31.6	12	.15	.20	.15
3.....	46.5	12	.15	.20	.15
4.....	40.5	15	.175	.20	.15
5.....	112.5	15	.175	.20	.15
6.....	49.4	20	.175	.20	.15
7.....	41.1	25	.175	.20	.15
8.....	43.7	25	.175	.20	.15
Average.....	49.5	17	.1656	.20	.15

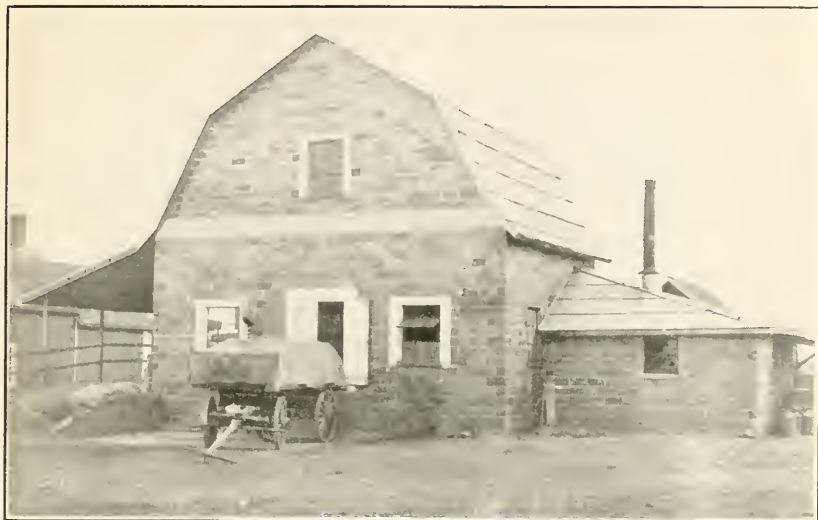


FIG. 1.—ONE OF THE NEWER COUNTRY STATIONS WHERE MILK WAS RECEIVED AND COOLED BEFORE BEING TRUCKED TO THE CITY OR TO THE RAILWAY SHIPPING POINT.

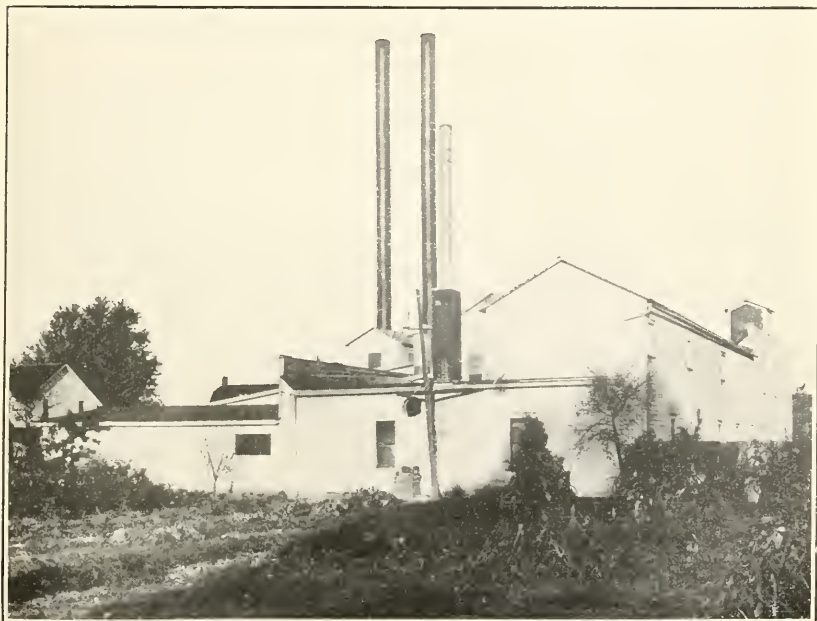


FIG. 2.—A CONDENSARY FROM WHICH SHIPMENTS OF MARKET MILK WERE MADE IN SUCH QUANTITIES AS WERE REQUIRED FROM DAY TO DAY.



FIG. 1.—INTERIOR VIEW OF A SPECIAL REFRIGERATOR CAR USED FOR TRANSPORTING MILK IN FIBER CONTAINERS FROM A COUNTRY MILK PLANT TO DETROIT.



FIG. 2.—A CITY PASTEURIZING AND BOTTLING PLANT HANDLING APPROXIMATELY 145 GALLONS DAILY AND SUPPLYING TWO DELIVERY WAGONS.

The total investment in plant and equipment was \$4,274, which was an average of \$29.48 per gallon handled daily.

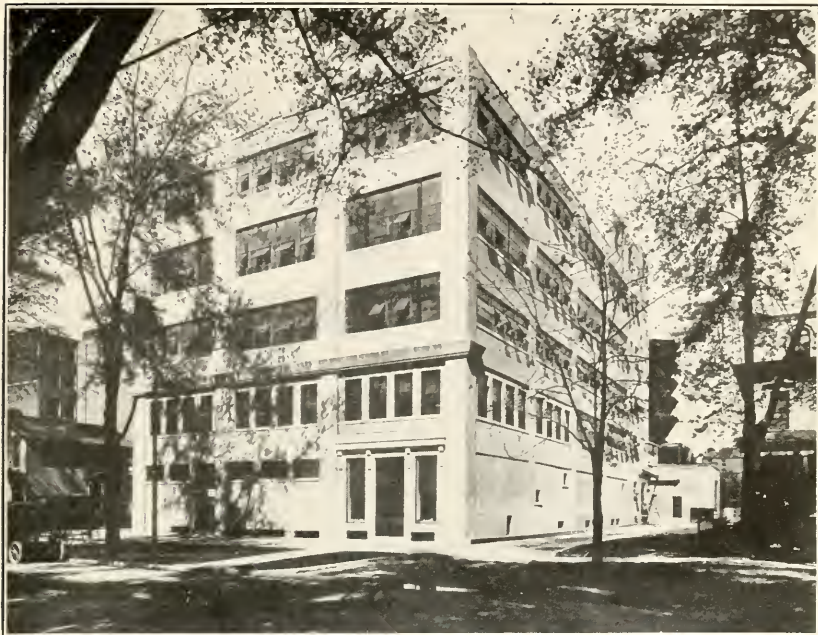


FIG. 1.—ONE OF THE LARGEST CITY MILK PLANTS, WITH A CAPACITY FOR HANDLING APPROXIMATELY 15,000 GALLONS DAILY.

The average per gallon investment for the group of largest plants in Detroit was approximately \$30.



FIG. 2.—ATTRACTIVE BUT EXPENSIVE EQUIPMENT.

The disproportionate per gallon investments in equipment between small and large dealers are caused mainly by the well-kept and attractive horses, barns, wagons, and wagon sheds. Such costly investments, however, together with other advertising expenses, are necessitated by competition.

In most cases the cost of trucking was less than the cost of transportation by steam railroad and the same as by electric road. It should be explained that electric lines did not serve those stations where costs of trucking were higher than the rates for equal distances on the electric railways.

When the milk was shipped by either steam or electric roads, an additional cost of about $1\frac{1}{2}$ cents for each 10-gallon can was usually incurred in trucking the milk from the city terminal milk platform to the city milk plant.

COST OF MILK DELIVERED TO THE CITY.

Figure 2 and Table III show the average prices paid by small, medium, and large dealers for milk f. o. b. Detroit. As shown in Table IV, the smaller dealers did not receive their supplies through country milk stations. To show the total cost of milk f. o. b. Detroit when received through country stations, and the relation of the costs of collecting and handling at these stations, the records of certain typical stations were obtained from a few dealers and are presented in Table XI.

TABLE XI.—*Relation of daily handling and transportation expenses at country plants to prices paid farmers and total cost of milk f. o. b. Detroit during June, 1915.*

Station number.	Paid farmers.		Costs of collecting and handling at country station.			Expenses of transporting to Detroit.		Total cost of milk f. o. b. Detroit.		
	Amount per day.	Net price per gallon.	Amount per day.	In per cent of amount paid farmers.	Cost per gallon.	Amount per day.	Cost per gallon.	Amount per day.	In per cent of amount paid farmers.	Total cost per gallon.
1.....	\$7.00	\$0.092	\$1.07	1.5	\$0.013	\$1.13	\$0.014	\$9.20	131.3	\$0.119
2.....	12.00	.098	1.06	8.8	.008	1.83	.014	14.89	124.0	.120
3.....	17.00	.099	1.10	6.4	.006	4.73	.027	22.83	134.2	.132
4.....	22.00	.098	1.62	7.3	.007	3.37	.014	26.99	122.6	.119
5.....	30.00	.095	2.19	7.3	.006	2.57	.008	34.76	115.8	.109
6.....	44.00	.116	2.34	5.3	.006	5.70	.014	52.04	118.2	.136
7.....	44.00	.100	1.24	2.8	.002	6.70	.014	51.94	118.0	.116
8.....	54.00	.117	3.06	5.6	.006	6.97	.014	64.03	118.5	.137
9.....	99.00	.128	9.56	9.6	.012	11.67	.014	120.23	121.4	.154
10.....	85.00	.102	8.09	9.5	.009	23.57	.027	116.66	137.2	.138
11.....	108.00	.108	3.70	3.4	.003	27.23	.026	138.93	128.6	.137
12.....	83.00	.115	17.54	21.1	.011	17.47	.011	118.01	142.1	.137
13.....	98.00	.148	14.48	14.7	.009	16.23	.010	128.71	131.3	.167
14.....	267.00	.141	10.13	3.7	.005	51.47	.026	328.60	123.0	.172
15.....	141.00	.114	4.81	3.4	.001	33.67	.013	179.48	127.2	.128
16.....	284.00	.107	8.18	2.8	.003	71.83	.026	364.01	128.1	.136
Average...	\$7.00	.113	5.63	7.0	.006	17.88	.017	110.70	126.3	.134

The "net prices" paid farmers at different stations during the month of June, 1915, varied from 9.2 cents to 14.8 cents a gallon. These prices are not the same as those quoted in the schedule of prices for milk delivered f. o. b. Detroit, but are what the farmers actually received at the particular stations after transportation costs had been

deducted. The average costs of collecting, handling, and transporting to city amount to approximately 25 per cent of the net price paid to the farmers. The last column of the table shows that the cost of milk delivered in Detroit varied considerably, depending upon where it was bought and the varying costs of collecting, handling at stations, and transportation to the city. The dealers paid varying prices in different communities, in accordance with the local competitive conditions and the city demands for market milk. There was no fundamental cost basis for the prices which then prevailed in the Detroit territory. (See also Table II and fig. 2.)

TRADE DEMANDS IN DETROIT.

The business of milk dealers usually consisted of a combination of wholesale and retail trade. The wholesale trade required milk and cream in both cans and bottles; hotels, restaurants, ice-cream manufacturers, and bakeries generally purchased bulk goods, while hospitals, sanitariums, saloons, and soda fountains required both bulk and bottled goods. Retail stores also bought bottled goods at wholesale prices. Prices paid by that class of trade varied greatly, depending largely upon the grade and quantity purchased, as well as upon changing market conditions. Wholesale prices for common milk generally fluctuated around 22 cents a gallon in bulk and 7 cents a quart in bottles.

The retail trade of milk dealers consisted of sales to families and (for luncheon) to office and factory workers. The retail price for common milk in Detroit during June, July, and August, 1915 (the time covered by this study) was about 8 cents a quart.

Table XII shows the variation of demand on retail milk routes.

TABLE XII.—*Variable demands of retail customers for milk, cream, and other milk products, by different retail routes.*

Number of customers on route.	Common milk.				Certified and special.				Cream.				Butter-milk.		Average daily sales.		Total bills receivable.	Average credit per customer.		
	Number of quarts.	Per cent of customers.	Number of pints.	Per cent of customers.	Number of quarts.	Per cent of customers.	Number of pints.	Per cent of customers.	Number of quarts.	Per cent of customers.	Number of half pints.	Per cent of customers.	Number of quarts.	Per cent of customers.	Per route.	Per customer.				
351.....	122	34.7	236	67.2	3	0.8	4	1.1	3	0.8	34	9.6	24	6.8	4	1.1	\$24.44	\$0.069	\$247.00	\$0.703
214.....	92	42.9	130	60.7	5	2.3					7	3.2	12	5.6	2	.9	14.50	.067	183.00	.855
343.....	156	45.4	215	62.6	4	1.1	5	1.4	4	1.1	43	12.5	25	7.2	8	2.3	27.70	.080	409.00	1.192
273.....	109	39.9	188	68.8	3	1.0	4	1.4	5	1.8	30	10.9	35	12.8	10	3.6	22.22	.081	261.00	.956
319.....	130	40.7	207	64.8	8	2.5		.6			28	8.7	28	8.7	10	3.1	24.02	.075	339.00	1.062
356.....	129	36.2	239	67.1							51	14.3	57	16.0	6	1.6	26.54	.074	351.00	.985
336.....	134	39.8	252	75.0	1	.2					12	3.5	1	.2	13	3.8	22.61	.067	234.00	.696
344.....	183	53.1	251	72.9	1	...	4	1.1			39	2.3	4	1.1	10	2.9	26.54	.077	321.00	.933
342.....	157	45.9	250	73.0	10	2.9	2	.5	2	.5	33	9.6	25	7.3	6	1.7	28.62	.083	440.00	1.286
125.....	70	56.0	70	56.0	2	1.6	2	1.6	3	2.4	20	16.0	12	9.6	7	5.6	11.83	.093	176.00	1.408
Average, 300.	128	42.6	204	68.0	3.7	1.2	2.3	.7	1.7	.5	26.6	8.8	22.3	7.4	7.6	2.5	22.90	.076	296.00	.986

The table shows also that the milk dealers of Detroit handled a variety of goods in various-sized containers, some of which were demanded by relatively few customers. This custom has developed because it was found advisable to supply the exact quantities in the kind and size of containers demanded. To increase the demand for

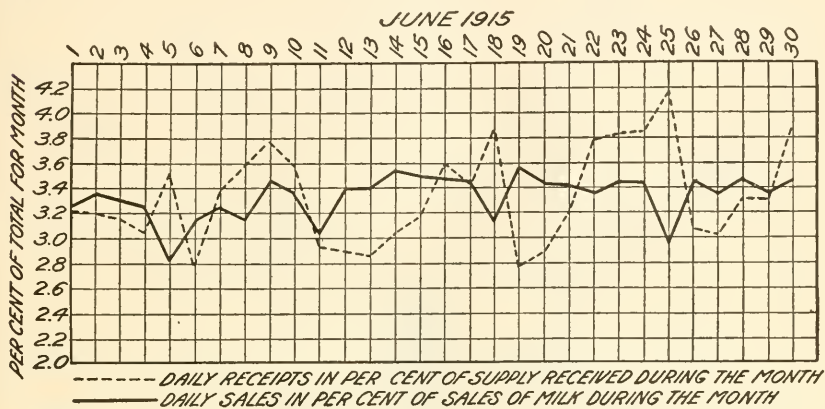


FIG. 4.—Daily fluctuation in receipts and sales of milk in per cent of total supply and sales for the month.

some special goods certain dealers often advertise them extensively, because it also tends to increase the sales of common milk and cream.

The fluctuating daily demands in relation to the monthly sales of market milk are illustrated by figure 4. The daily sales of market

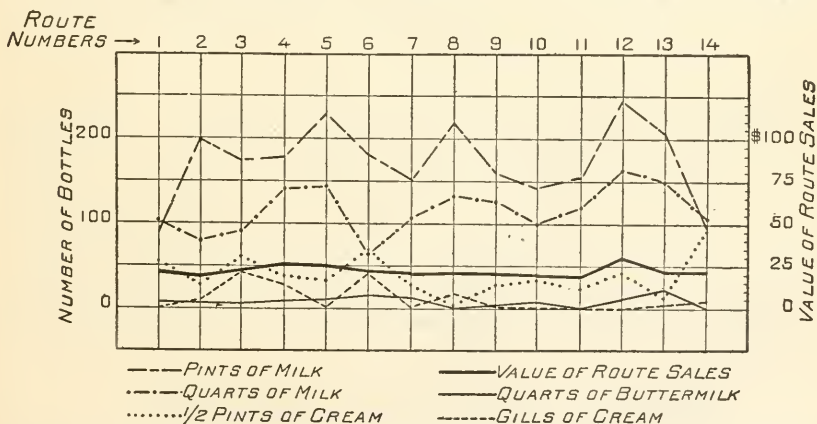


FIG. 5.—Chart showing one day's sales on 14 retail routes serving approximately an equal number of customers.

milk are shown in per cent of the total sales for the month. In order to furnish the exact quantities of goods that might be required by the trade at any time and hold the business, it was necessary for milk dealers to have on hand a sufficient quantity of goods to supply all probable demands. To avoid excessive losses from surplus



FIG. 6.—Location of city milk plants in Detroit before compulsory pasteurization.

quantities which were not needed by the trade, dealers utilized the surplus by manufacturing it into some less perishable product, such as butter, cheese, or condensed milk.

The various demands of consumers for goods put up in different-sized containers are graphically illustrated in figure 5. Although there were approximately an equal number of customers on each of the 14 routes, and though the value of sales was approximately the same, the demands for goods in different-sized containers varied greatly. To supply the demands for market milk and its derivatives it was necessary for dealers to equip their plants properly for distributing in the city the milk received from various producers in the country.

PREPARING MILK FOR CITY DISTRIBUTION.

BEFORE COMPULSORY PASTEURIZATION.

Prior to the enforcement of the milk-pasteurization ordinance there were 158 milk dealers in Detroit, and the "plants" were situated in different parts of the city, as shown in figure 6. Twenty-four dealers used the "flash" method of pasteurization and 19 the "holding" process. There were 91 dealers who bottled raw milk, each

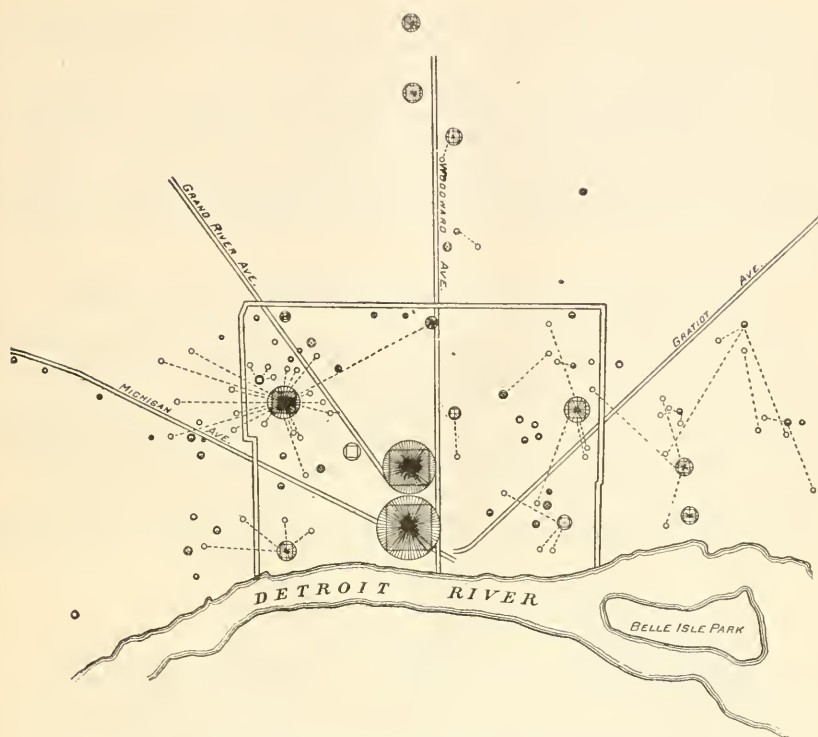


FIG. 7.—System of city distribution of market milk in Detroit after compulsory pasteurization.

handling from 40 to 1,500 gallons daily. Only a few of the smaller plants were equipped with steam boilers, the greater portion using gas heaters to furnish hot water for washing the milk bottles and utensils. Forty-four dealers purchased pasteurized milk in bulk from 23 other dealers, which they bottled and sold to both retail and wholesale trade.

The records of the Detroit Board of Health showed higher bacterial counts in milk pasteurized by the flash method than that pasteurized by the holding method. The pasteurized milk which was purchased from other dealers often showed higher bacterial counts than the samples of the raw milk before pasteurization. The bacterial counts were usually higher in the pasteurized milk purchased from other dealers for bottling than in that which was pasteurized and bottled in the same plant.

AFTER COMPULSORY PASTEURIZATION.

The pasteurization ordinance which became effective May 1, 1915, required that all milk be pasteurized by the holding process in plants equipped in accordance with regulations adopted by the milk-inspection department of the city board of health.

August 1, 1915, three months after the pasteurization ordinance became effective, there were 68 plants in which milk was prepared for market distribution. Approximately 75 per cent of the total milk supply was pasteurized by 11 dealers whose average daily output per plant was more than 3,600 gallons. About 10 per cent of the city's milk supply was distributed by small dealers who purchased their supplies from other dealers who operated pasteurizing plants. (See fig. 7.)

CAPITAL INVESTED AND COST OF HANDLING MILK AT CITY PLANTS.

To show the investments required for milk plants and equipment, and the varying costs of handling milk in preparing it for distribution in the city, the records of 28 representative dealers were obtained. Table XIII shows the varying investments in relation to the operating costs in the plants, according to increasing costs of handling.

TABLE XIII.—*Relation of cost of handling to capital investments, supplies, and labor in twenty-eight city milk plants.*

Handling cost per gallon. ¹	Gallons handled daily.	Investments.		Supplies. ²		Labor.	
		Total.	Per gallon handled daily.	Per day.	Per gallon.	Per day.	Per gallon.
<i>Cents.</i>					<i>Cents.</i>		<i>Cents.</i>
2.3	1,600	\$13,300	\$8.31	14.96	0.9	\$13.68	0.9
2.4	350	4,320	12.34	11.84	1.2	1.99	.6
2.6	9,706	267,575	27.57	70.01	.7	167.82	1.7
2.6	2,000	16,824	8.41	16.57	.8	27.21	1.4
2.7	850	7,154	9.54	5.48	.7	10.68	1.4
2.8	1,450	41,643	28.72	9.76	.7	14.25	1.0
3.1	1,450	18,720	12.90	18.42	1.3	17.03	1.2
3.3	220	1,917	8.71	2.45	1.1	3.81	1.7
3.3	340	3,502	10.30	3.24	1.0	5.98	1.8
3.4	470	2,527	5.38	4.87	1.0	9.86	2.1
3.6	400	5,312	13.28	4.20	1.0	7.40	1.9
3.7	165	3,029	18.36	1.95	1.2	2.71	1.6
3.8	2,119	97,457	45.99	11.79	.6	47.31	2.2
3.9	425	7,595	17.87	5.61	1.3	7.12	1.7
4.4	335	4,542	13.56	5.43	1.6	5.98	1.8
4.4	100	1,186	11.87	1.64	1.6	2.00	2.0
4.5	310	3,847	12.41	5.18	1.7	5.84	1.9
5.2	230	4,927	21.42	2.35	1.0	7.13	3.1
5.2	1,300	7,315	5.63	36.10	2.8	9.97	.8
5.3	100	1,829	18.29	1.18	1.2	2.99	3.0
5.4	240	7,141	29.75	3.70	1.5	6.04	2.5
5.4	530	20,251	38.21	6.76	1.3	10.54	1.0
6.1	135	1,829	13.55	1.57	1.2	5.60	4.1
6.8	85	2,705	31.82	1.24	1.5	3.00	3.5
6.8	1,260	110,592	87.77	33.78	2.7	21.80	1.7
7.0	145	4,274	29.48	3.58	2.5	4.70	3.2
7.1	90	2,762	30.69	2.18	2.4	2.56	2.8
7.2	40	1,725	43.13	.51	1.3	1.50	3.8
Ave. 4.4	940.9	23,778	21.97	10.23	1.4	15.23	2.01

¹ These unit costs include charges for depreciation and interest on capital invested, supplies, and labor expenses (all the items which could be definitely charged against handling in plant).

² Supplies include charges for fuel, ice, power and light, bottles, caps, washing powder, brushes, etc.

A study of the table reveals rather wide variations in the costs of handling milk in the different plants, many of which are caused by the varying proportions of bottled and bulk milk handled. The

average costs per gallon handled at the different plants, therefore, are not exactly comparable, for it does not cost so much to pasteurize and put into cans the milk sold to other dealers or to wholesale trade as it does to pasteurize and bottle milk for the retail trade.

It is important to note the disproportionate investments in milk plants and equipment. The investments per gallon handled daily range all the way from \$5.38 to \$87.77, and illustrate the lack of standardization of milk plants and equipment. It is obvious that a relatively low investment greatly reduces the interest and depreciation charges against each gallon handled. In those plants where the operating costs per unit were the lowest, the investments per gallon were generally comparatively small and the expenditures for supplies and labor in proportion to capital invested were greater. (See Pl. II, fig. 2, and Pl. III, fig. 1.)

Some of the disproportionate investments may be accounted for by the fact that some plants were old and handled a large proportion of bulk milk, whereas others were newly built for the purpose of increasing the business.

CITY DISTRIBUTION OF MILK.

The number of milk dealers engaged in the business of distributing milk in Detroit, August 1, 1915, and the size of the business of those dealers grouped according to number of delivery wagons operated, are shown in Table XIV.

TABLE XIV.—*Quantity of milk and cream distributed daily by dealers (grouped according to number of wagons operated).*

Number of wagons.	Number of dealers.	Total number of wagons.	Average number of wagons per dealer.	Gallons sold daily.		Per cent of total.
				Milk.	Cream.	
1 to 5.....	127	201	1.5	15, 179	271	28.8
6 to 15.....	7	80	11.4	8, 340	367	16.3
16 to 30.....	4	70	17.5	6, 050	215	11.7
31 to 150.....	2	235	117.5	18, 000	5, 100	43.2

On August 1, 1915, there were 140 milk distributors, or 18 fewer than on May 1, when the pasteurizing ordinance became effective. Of these dealers 127 operated from 1 to 5 wagons each. Two of the larger companies, operating more than 30 delivery wagons each, together distributed nearly 44 per cent of the total milk supply of the city.

Figure 7 is a graphic presentation of the system of distribution which prevailed in August, 1915. The locations of the milk-pasteurizing and bottling plants are indicated by squares. The areas of the squares represent the relative quantities of milk pasteurized in the

plants. The small circles indicate the location of the different dealers in the city. The number of radii within the circle represents the number of delivery routes operated by each dealer. When a dealer purchased his supply from a pasteurizing and bottling plant, a broken line shows his connection with the plant from which the supply was obtained. A comparison of the map with figure 6, which presents conditions on May 1, 1915, shows that the number of city milk plants was reduced on August 1, but that the number of milk dealers had not decreased greatly.

In addition to the dealers referred to in figure 7 there were two dealers who operated plants in the country where milk was pasteurized, bottled, and shipped to Detroit. By selling to hotels, restaurants, and factories it was possible for one of the suburban plants to sell practically its entire supply at wholesale. The other plant bottled a considerable portion of its supply in the country, and either shipped the remainder in bulk to the city or manufactured it into cheese. This plant used fiber containers instead of glass bottles for goods sold in retail quantities. Instead of delivering direct to consumers, which would have required an investment in retail delivery equipment and the maintenance of a city sales organization, arrangements were made with grocery stores to retail the milk. There were some objections to the use of fiber containers, but storekeepers generally accepted them, because no losses were incurred by the failure of customers to return the empty bottles. The use of these containers was very successful for that class of trade.

Table XV shows the proportion of retail and wholesale trade of dealers handling different quantities of milk.

TABLE XV.—*Relation of retail to wholesale business.*

Number of wagons.	Average number of wagons per dealer.	Quarts sold daily.		Per cent sold.	
		Retail.	Wholesale.	Retail.	Wholesale.
1 to 5.....	1.5	34,752	25,964	57.2	42.8
6 to 15.....	11.4	20,700	12,660	62.0	38.0
16 to 30.....	17.5	12,900	11,300	53.3	46.7
31 to 150.....	117.5	45,600	26,400	63.3	36.7

Different dealers had various proportions of wholesale and retail business, and there was no definite relation between the quantity of milk handled and the proportion of wholesale to retail sales.

The relation of the size of a dealer's business to the daily variation in quantities of market milk sold at wholesale and retail is shown in figure 8. While the records of both the larger and smaller dealers showed considerable variation in their total daily sales, the sales of

the larger companies fluctuated less than those of the smaller ones, possibly because their ownership of country stations enabled them to provide an ample supply and better facilities for utilizing any surplus. The smaller concerns, because of the comparatively small quantities handled, usually found the manufacture of by-products to be less profitable than the selling of a temporary surplus to wholesale trade even at greatly reduced prices.

The small dealers usually made both wholesale and retail deliveries from the same wagon, while the larger dealers generally operated their wholesale routes separately. Because of the irregular and exacting service required by the wholesale trade, a large part of the sales to that class of trade is often made by special delivery trucks. Figure 8 gives a graphic presentation of the comparative amounts of wholesale business of large dealers handled by special delivery.

Table XVI shows the investment required for delivery equipment in relation to the cost of delivering milk from city plants to the various classes of trade.

TABLE XVI.—*Relation of costs per quart delivered to investments in delivery equipment, average number of quarts delivered per wagon, and per cent of sales at retail for 28 dealers.*

Cost per quart. ¹	Investments in delivery equipment.		Number of delivery wagons.	Average quarts delivered per wagon daily.	Per cent of sales at retail.
	Total.	Per gallon delivered daily.			
<i>Cents.</i>					
0.5	\$1,005.00	\$3.24	1	1,240	0.0
.8	956.00	4.35	3	293	77.3
.9	1,527.00	9.25	1	660	50.0
1.1	14,899.10	8.92	14	477	54.5
1.2	527.50	4.06	2	260	73.1
1.2	7,280.00	6.31	12	384	62.5
1.2	2,480.00	6.12	4	405	47.1
1.2	8,779.00	6.05	14	414	93.3
1.2	870.00	8.70	1	400	77.2
1.3	2,907.00	12.11	3	320	60.0
1.3	1,180.00	8.74	1	540	77.3
1.3	40,050.85	18.90	14	605	58.9
1.4	170,090.04	17.52	99	392	81.3
1.4	15,055.50	9.45	16	400	53.3
1.4	692.00	8.14	1	340	62.5
1.4	2,096.00	6.45	3	433	76.9
1.4	8,779.00	6.86	14	366	34.5
1.5	3,030.00	10.10	4	300	65.0
1.5	1,160.00	4.64	5	200	50.0
1.5	1,595.50	6.94	3	307	73.8
1.5	575.00	14.38	1	160	85.0
1.6	1,570.00	17.44	2	180	61.5
1.6	2,740.00	8.06	4	340	74.5
1.6	7,375.00	17.35	4	425	65.0
1.7	785.50	7.85	2	200	64.3
1.7	2,623.33	7.83	3	447	71.4
1.8	2,831.50	5.34	6	353	80.0
2.5	29,225.35	23.19	20	252	56.9
² 1.38	² 11,881.75	² 9.58	² 9	² 396	² 63.9

¹ These unit costs do not include items of administration, office expenses, advertising, licenses, insurance, taxes, and other miscellaneous expenses.

² Average.

Table XVI shows that the cost of delivering a quart of milk in the city is dependent upon many things besides the average number of quarts delivered daily by each delivery wagon. The most economical delivery was effected by a dealer who sold bottled milk exclusively, but delivered in relatively large quantities to retail stores only. The dealer whose delivery cost per quart was the highest had comparatively small average sales per wagon in relation to the proportion of sales made to wholesale trade. The figures suggest possible economies in milk distribution if all sales were made through the medium of established retail stores. The table, however, does not indicate the cost of delivering to the consumer by the retail stores.

The item "investments in delivery equipment" includes horses, barns, wagon sheds, automobile trucks, delivery wagons, and sundry articles used in delivering milk. The reasons for the wide variations

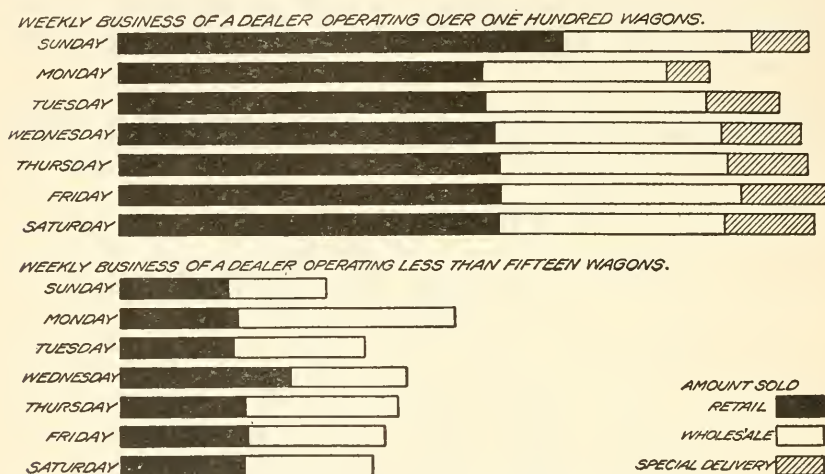


FIG. 8.—Relation of size of business to fluctuations in daily sales at wholesale and retail.

in delivery investments per gallon delivered are the varying proportions sold at wholesale, and the fact that some of the larger dealers had unusually high-priced horses and very costly stables. Such unusually large investments in delivery equipment are maintained for advertising as well as for direct utility. (Pl. III, fig. 2.)

Figure 9 illustrates the cost of city delivery in relation to amount of sales on 14 city delivery routes. Routes Nos. 1, 7, and 9 were engaged in a strictly wholesale delivery of bottled milk to retail stores, restaurants, and hotels. The business on the other routes consisted mainly of retail delivery at the family door, with only a few deliveries to grocery stores.

The heavy line in the figure shows the variation in the value of daily sales on the routes. Pasteurizing and bottling expenses at the city plant are included in the item "cost of goods." The item "cost

of goods and selling expenses" does not include overhead charges for taxes, administrative expenses, or losses occasioned by breakage or spoilage of goods on routes. The chart is designed to show the profit from business on different sales routes. Some routes show a good margin of profit, while others are run at an actual loss. The dealer who would expand his business under existing competition often finds it advisable to build up new routes at the expense of other routes which are profitable. Such expenses are the inevitable results of any competitive system of distribution. Figure 9, like Table XVI, suggests that considerable savings in delivery costs can be effected through a more centralized distributing organization.

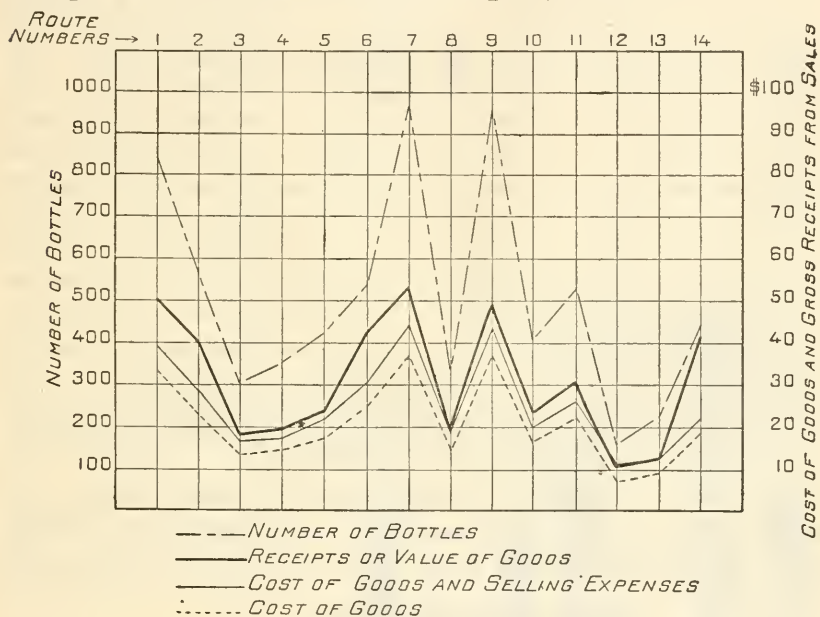


FIG. 9.—Average number of bottles delivered and value of sales in relation to cost of goods and expenses of delivery on 14 selected routes.

SUMMARY OF COMPARATIVE COSTS OF HANDLING AND DISTRIBUTING MILK.

In the foregoing tables and figures only such expenses were included as might be definitely allocated or fairly apportioned to either the expenses of handling milk in plants or of delivering in the city. Miscellaneous expenses, insurance, taxes, and charges for advertising, administrative, and office expenses were not included in any tables or graphs. In order to bring out some of the comparative advantages and disadvantages of small and large businesses, these items of expense are included in Table XVII, which shows the average per gallon investments and expenses of 28 dealers grouped according to the number of gallons handled daily.

TABLE XVII.—Comparative investments and costs per gallon of handling and distributing milk by 28 dealers grouped according to quantities handled.

Dealers grouped according to number of gallons handled daily.			For handling.					For delivery.					For administration.												
Range of gallons handled.	Average of group.	Investment per gallon handled daily.	Interest and depreciation.	Supplies. ¹	Labor.	Investment per gallon handled daily.	Interest and depreciation.	Supplies. ²	Labor.	Investment per gallon handled daily. ³	Interest and depreciation.	Supplies. ⁴	Salaries. ⁵	For advertising.	For licenses, insurance, and taxes.	For miscellaneous expenses.	Total of all expenses.								
Less than 150.....	Galls 99	\$23.725	Cts. 1.2	Cts. 1.7	Cts. 3.20	\$9.117	Cts. 0.48	Cts. 1.08	Cts. 3.36	Cts. .000	Cts. .002	Cts. .10	Cts. 0.5	Cts. .00	Cts. 0.10	Cts. .00	Cts. 11.72								
151 to 500.....	315	13.870	.6	1.3	1.8	8.348	.38	.91	2.94	0.489	0.02	.09	.73	.....	.08	.....	8.85								
501 to 1,000.....	640	21.535	1.0	1.0	1.7	6.404	.39	.85	3.50	.165	.007	.10	1.30	.....	.04	.....	9.90								
1,001 to 1,500.....	1,365	32.485	1.2	1.8	1.2	10.039	.54	1.01	3.46	.516	.02	.02	.90	.....	.04	.01	10.20								
1,501 to 2,000.....	1,800	8.395	.4	.9	1.1	9.160	.61	.83	2.54	.183	.01	.10	.70	.....	.05	.03	7.30								
2,001 to 3,000.....	2,119	45.625	1.0	.6	2.2	18.980	.43	.92	3.69	.730	.04	.40	.70	.30	.20	.06	10.50								
More than 3,000.....	9,706	27.375	.2	.7	1.7	17.520	.21	1.29	4.01	6.570	.29	.25	.43	.05	.20	.....	9.30								
Average of all groups..	2,292	24.715	.8	1.142	1.842	11.3666	.43	.98	3.36	1.236	.0645	.151	.751	.175	.091	.003	9.819								

¹ See note below Table XIII, page 18.² Supplies for delivery include charges for horse feed and shoeing, lanterns, automobile supplies, milk carriers, etc.³ Investment for administration include office furniture and appliances.⁴ Supplies for administration include office supplies, such as route books, accounting forms and books, tickets, stationery, electric lights, etc.⁵ Salaries for administration include salaries of office clerks and administrative officers. In some plants only a part of a man's salary was charged to the item, as some of the time was charged directly to labor for either handling or delivery.

Table XVII and figure 10 show that on the average the cost of handling milk is less in the larger-sized plants than in the smaller ones. The groups handling daily from 1,001 to 1,500 gallons and

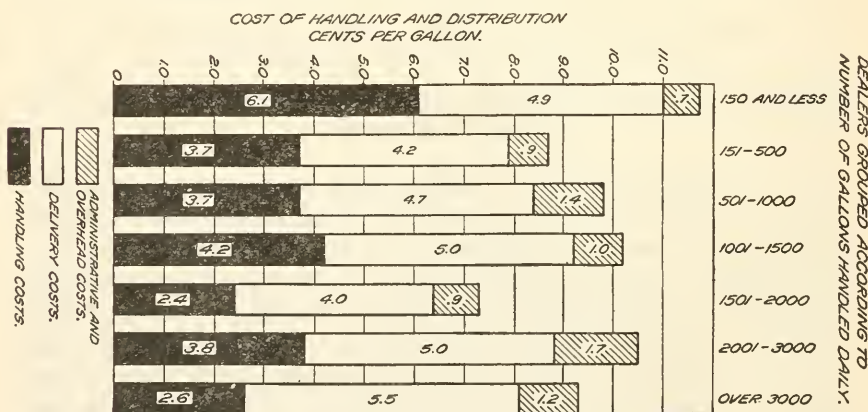


FIG. 10.—Cost of handling and distributing a gallon of milk.

from 2,001 to 3,000 gallons do not conform strictly to the general tendency, because the plants in these groups had large investments in buildings and equipment, and were not operated at full capacity in all cases. The delivery costs per gallon do not vary in accordance with the size of the business; the reasons are indicated in Table XVI and figure 9.

Figure 11 shows graphically the differences in per gallon investments by dealers, grouped according to number of gallons handled daily. The extremely disproportionate investments for both handling and delivering are explained in the discussion following Tables XIII and XVI. The general tendency, however, was for the handling investment to increase with the size of the plant to the point of a plant handling as high as 2,001 to 3,000 gallons. The group handling 1,501 to 2,000 gallons has a disproportionately low investment because in that group the dealers had equipped some old wooden buildings for temporary use until thoroughly modern plants could be constructed and satisfactorily equipped. Plants handling less than 150 gallons present another exception to the general tendency which in part can be explained by the fact that they were not operated at full capacity. The figures would also indicate that unless a dealer can handle at least 150 gallons his plant investment charge will be high. It will be noted that in general the larger dealers had greater investments in delivery equipment than the smaller ones. That is in part explained by the fact that many of

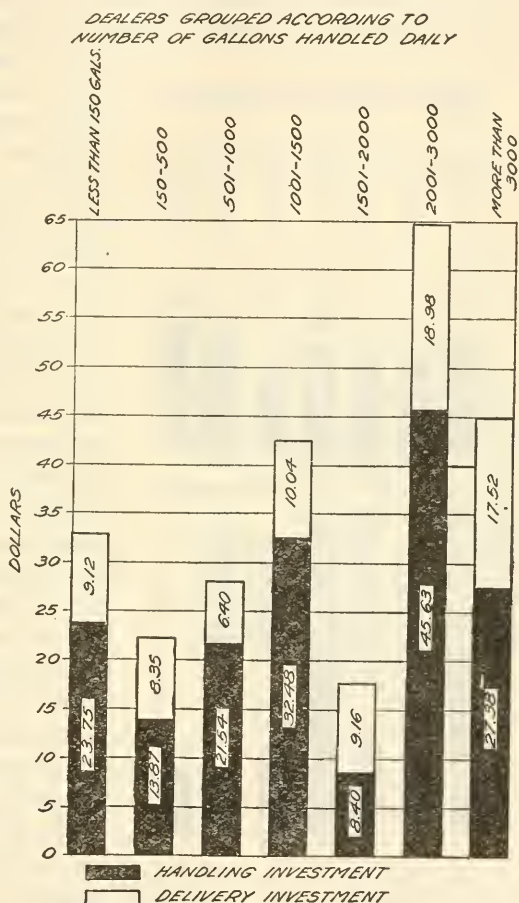


FIG. 11.—Average investments per gallon for handling and distributing milk.

the larger dealers maintained expensive barns and wagons, while some of the smaller ones had much less costly delivery outfits.

The differences in costs of supplies and in the charges for interest and depreciation are in the main the result of differences in the per gallon investments. Figure 12 shows radical differences in the cost of supplies in milk plants. As many of the dealers had operated their newly equipped plants for only a short time, and since some plants were not arranged efficiently or were not operated at full capacity, the most economical use of supplies was not possible.

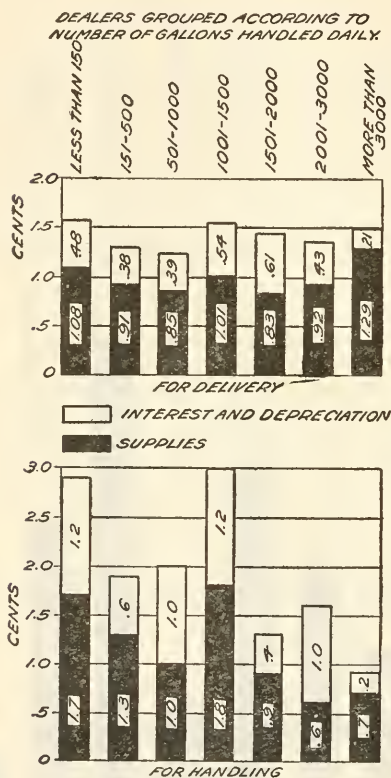


FIG. 12.—Variations in charges for interest and depreciation and cost of supplies per gallon.

Aside from advantages of business experience, however, and differences in the extent to which machinery was run at full capacity, the larger dealers were able to effect considerable economies by the purchase of supplies in large quantities.

Figure 13 shows that the larger dealers have lower labor costs per gallon in plant operations than the smaller plants, owing to the economies effected through specialization of labor. The apparent exception in the case of the two larger groups is to be explained by the fact that a larger proportion of their output consisted of bottled goods than in the case of the smaller plants. In delivering milk, however, there appears to be no definite relation between the size of the business and the per gallon labor costs.

The figures of the comparative costs in Table XVII represent the expenses of handling at the city plant and of delivering to the various classes of trade. They do not include, however, such expenses as are imposed on the business by surplus milk, soured or spoiled milk, shrinkage in handling, shortages on delivery routes, and bad bills. These items of loss or expense of the business were not obtainable from many dealers, because of a lack of efficient business organization or inadequacy of accounting systems to check such losses. On account of the omission of those items of expense, Table XVII possibly does not bring out all the comparative economies of large

various classes of trade. They do not include, however, such expenses as are imposed on the business by surplus milk, soured or spoiled milk, shrinkage in handling, shortages on delivery routes, and bad bills. These items of loss or expense of the business were not obtainable from many dealers, because of a lack of efficient business organization or inadequacy of accounting systems to check such losses. On account of the omission of those items of expense, Table XVII possibly does not bring out all the comparative economies of large

and small businesses. (See fig. 10.) The losses from spoilage and temporary surplus or shortage of a supply of milk were comparatively less for the larger dealers. In the case of all dealers, regardless of the size of their business, the losses from bad bills were small. Through the use of the ticket system a large part of the retail business was done on advance payments.

It is noteworthy that only the larger dealers had expenses listed under the item of advertising. Practically all the dealers had expenses which may have been properly listed under that item, but were listed under either administrative or miscellaneous expenses. Besides the readily recognized expenses of advertising, practically all the dealers made contributions or gifts of various kinds to gain or retain the good will of consumers. The comparatively expensive delivery equipment of the larger dealers also has a certain advertising value, although such expenses are not listed under that item.

In this connection it is important to note the lack of uniformity in provision made for the administrative end of the business, but in general the administrative expenses, which included office expenses, tended to increase in proportion to the size of the business. The smallest dealers had practically no administrative investments. See Table XVII.) Though the larger dealers generally had better administrative organizations, the personal supervision which the smaller ones were able to give to the business was an important factor in lowering their expenses.

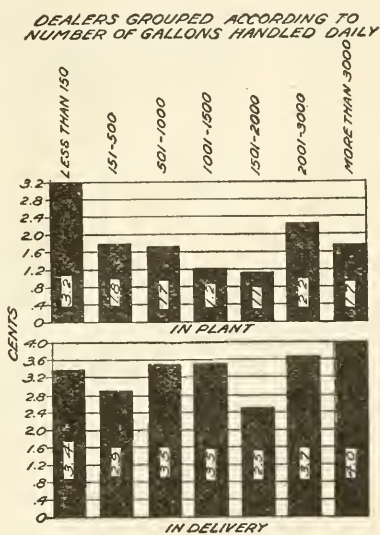


FIG. 13.—Variations in cost of labor per gallon.

CONCLUSIONS.

1. The demands for market milk in Detroit necessitated arrangements for obtaining a supply from farmers living too far from the city to effect an economical distribution of their comparatively small production. (Fig. 1 and pp. 2-4.)

2. The prices paid to farmers by the various dealers competing with one another in the market milk business of the city varied considerably. Milk dealers as well as the farmers were dissatisfied with conditions then existing. (Figs. 2 and 3 and pp. 4-7.)

3. A lack of standardization in the construction and equipment of country milk stations contributed largely to the varying costs of handling milk in the country. (Pl. I and pp. 8-10.)

4. Because they owned the country milk stations the larger dealers were able to obtain milk more cheaply in relatively distant areas of production. (Pl. I and pp. 12-14.)

5. Inconvenient train schedules, lack of satisfactory refrigeration facilities, and comparatively high transportation rates prevented some dealers from obtaining a supply of milk from certain areas of production. (Fig. 1; Pl. I, fig. 1; Pl. II, fig. 1, and pp. 3, 11-14.)

6. The fluctuating daily demands for market milk and its various derivatives in the city necessitate the use of proper equipment for handling and distributing milk and for the economical utilization of temporary surpluses (Fig. 4 and pp. 14-16.)

7. The variation in costs of preparing milk for city distribution was caused primarily by a lack of standardization in plant construction and equipment, and by the fact that some plants were not run efficiently or at full capacity. (Figs. 11 and 12; Pl. II, fig. 2; Pl. III, fig. 1, and pp. 18-19.)

8. The low cost of delivering milk in wholesale quantities to retail stores suggests possible economies by dealers if such a system of distribution were practiced by all. (Fig. 9; Pl. III, fig. 2, and pp. 19-23.)

9. The cost of handling and distributing in the city does not vary directly in proportion to the number of gallons handled, although the larger dealers do effect certain economies not possible to the smaller ones. (Figs. 11, 12, and 13 and pp. 23-27.)

10. In the case of many dealers there was evidence of administrative weaknesses which affected not only the internal economies of the business but also the relations of the business with producers and consumers. (P. 27.)

UNITED STATES DEPARTMENT OF AGRICULTURE
BULLETIN No. 640

Contribution from the Bureau of Entomology
L. O. HOWARD, Chief

Washington, D. C.



April 8, 1918

THE MEDITERRANEAN FRUIT FLY

By

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Entomologist, Mediterranean and Other
Fruit Fly Investigations

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ONE OF THE WORST enemies of fruit grown in tropical and semitropical countries is the Mediterranean fruit fly. Constant vigilance is necessary to prevent its establishment in North America. It is particularly destructive because it is difficult to control and attacks many kinds of fruits, nuts, and vegetables. In the Hawaiian Islands, where it has caused great damage since 1910, it attacks 72 kinds of fruits. A partial list of these contains oranges, grapefruit, lemons, limes, kumquats, tangerines, peaches, apples, figs, apricots, bananas, mangoes, avocados, sapotas, loquats, persimmons, guavas, quinces, papayas, pears, plums, grapes, eggplant, tomatoes, and even cotton bolls. Most of these are now grown or can be grown in our Southern States, the Gulf region, and California and the Southwest.

The purpose of this bulletin is to give alike to the citizen of Hawaii, the fruit grower of the United States mainland, and the traveler information that will help to convey a clear conception of the difficult problem that has developed with the introduction of the Mediterranean fruit fly into the Hawaiian Islands. The pest can be kept out of the rich semitropical fruit-growing sections of the United States only by the hearty and intelligent cooperation of all.



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THE HORTICULTURAL DEVELOPMENT of the Hawaiian Islands has been almost stopped since 1910 by the activity of two fruit-fly pests—the Mediterranean fruit fly¹ and the melon fly.^{2 3}

These two pests are being intercepted continually by quarantine officials at our ports of entry and they are therefore feared by, and are of vital interest to, every fruit and vegetable grower in the warmer portions of the Pacific and Gulf coast States. Every possible barrier to the establishment of these pests on the mainland United States is being erected by the Federal Horticultural Board, working in cooperation with State officials. Quarantines now regulate the movement of horticultural products from infested countries; hence the greatest danger to California, Florida, and Mexican territory now lies in the unintentional spread of fruit-fly pests by uninformed travelers who may carry infested fruits upon their persons or in their baggage.

The Mediterranean fruit fly (fig. 1) is one of the recently introduced pests of Hawaii. It has found climatic and food conditions so favorable that at present there is not a family unaffected by its ravages. It is doubtful if there exist in any other place in the world conditions so favorable to the rapid spread and thorough establishment of this pest as those in the Hawaiian Islands.

¹ "The Mediterranean Fruit Fly in Hawaii," E. A. Back and C. E. Pemberton, Department of Agriculture Bulletin 536. (*Ceratitis capitata* Wied.)

² "The Melon Fly in Hawaii," E. A. Back and C. E. Pemberton, Department of Agriculture Bulletin 491. (*Bactrocera cucurbitae* Coq.)

³ "The Melon Fly," E. A. Back, C. E. Pemberton, Department of Agriculture Bulletin 643.

NOTE.—The manuscript of this paper was prepared for publication as a Farmers' Bulletin, but owing to the fact that it deals with an insect which has not yet been introduced into the United States it was considered more appropriate to issue it in the series of Department Bulletins.

DISTRIBUTION THROUGHOUT THE WORLD.

The Mediterranean fruit fly is a cosmopolitan pest. It has been known to science for 100 years and during these years has spread throughout the world, until to-day the North American continent is the only large land area upon which it has not become established. It first attracted serious attention in London, where oranges arriving from the Azores were discovered to be badly decayed and wormy. (See fig. 2.) It was recorded as a pest in Spain in 1842, in Algeria in 1858, in Italy in 1863, in Sicily in 1878, and in Tunis in 1885. In 1889 it was first reported in South Africa. It became established in the western part of Australia in 1897 and in the eastern part in



FIG. 1.—Adult male Mediterranean fruit fly. Greatly enlarged. (Howard.)

1898. In 1899 it was detected in Tasmania, in 1900 it was found attacking the apricot orchards near Paris, France, and during 1901 it was reported from New Zealand and Brazil. Compere, in 1904, found the pest in Egypt, and in Asiatic Turkey at Beirut and Jerusalem. Argentina was reported infested in 1905. Between 1909 and 1914 it was found in the eastern and western parts of Africa, and in 1915 it was first reported from the Island of Madagascar. During 1916 it caused serious damage to the orange, tangerine, peach, pear, and apple crops of the Patras consular district of Greece. It is claimed that this was the first time in 10 years or more that this pest had been noticed in this district of Greece. The Bermuda Islands became infested during 1865.

ESTABLISHMENT AND SPREAD IN HAWAII.

The presence of the Mediterranean fruit fly in the Hawaiian Islands was first discovered at Honolulu on June 21, 1910, and by the fall of that year the pest was well established in the Punchbowl district of the city. By October, 1911, it was found on the Island of Kauai, and by January, 1912, on the Island of Molokai and in the Kohala district of the Island of Hawaii (see fig. 3). During March, 1912,

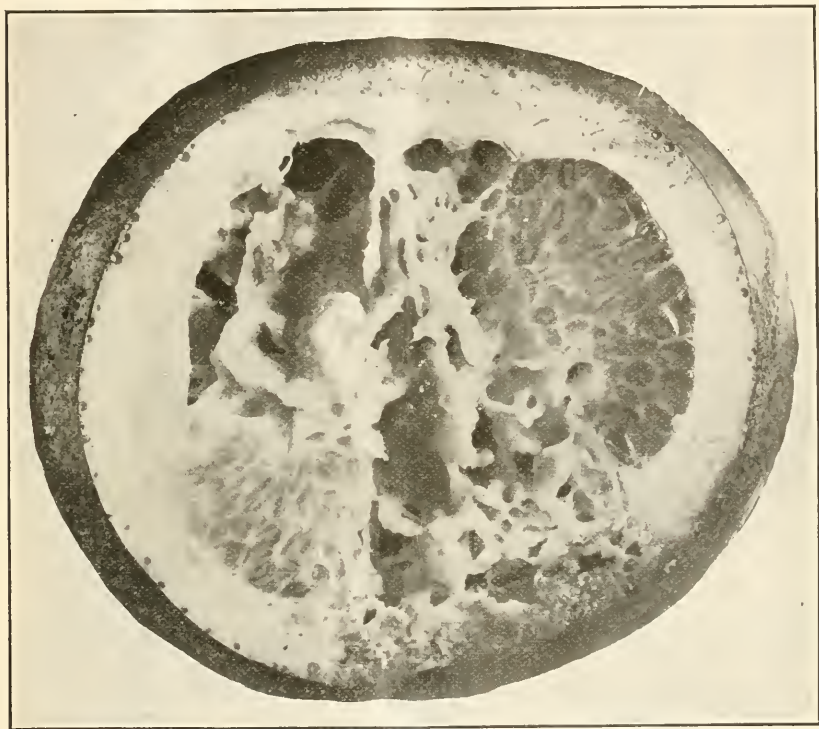


FIG. 2.—Longitudinal section of grapefruit showing destruction of pulp caused by larvae of Mediterranean fruit fly. (Original.)

the Kona district was found infested, and by May of the same year the fruit fly was discovered for the first time on the Island of Maui. The towns of Naalehu and Hilea of the Kau district of Hawaii were infested by March, 1913, and by the early months of 1914 infestations were found in the Hilo and the Hammakua districts of the same island. By July, 1914, or four years after its first discovery at Honolulu, the pest had spread to every important island of the Territory of Hawaii and to-day is well established in every village and wild guava scrub.

HOW THE FRUIT FLY GOT INTO HAWAII.

A number of popular accounts tell how the Mediterranean fruit fly became established in Honolulu, but they are without foundation.

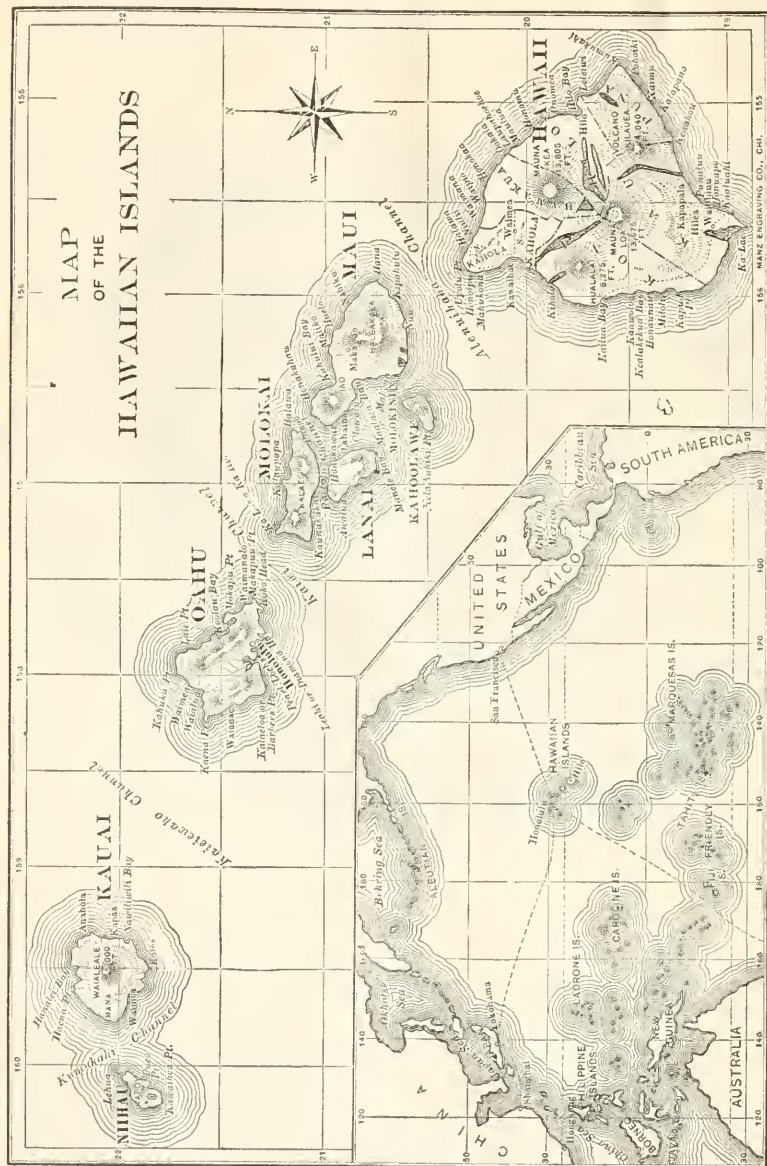


FIG. 3.—Map of Hawaiian Islands showing their relative position and relation to one another in the distribution of the Mediterranean fruit fly.

Establishment came as a natural sequence of the development of rapid ocean travel and cold storage, aided by unusually favorable shore conditions about the harbor of Honolulu. Hawaii was in no danger of infestation until 1898. Before that year ships touching

at Honolulu plied between countries not infested by this pest. Eastern Australia was not infested before 1898. With the development of rapid ocean transportation and cold storage on ships, the Mediterranean countries were enabled profitably to export oranges to Australia, and it was in these shipments of fruits that the fruit fly reached Australian shores and became established about Perth and Sydney.

Establishment in Hawaii at Honolulu followed naturally the commercial jump of the pest from the Mediterranean countries to Australia. Honolulu is a port of call for ships plying between eastern Australian ports and San Francisco and Vancouver, and the voyage of about two weeks required for passage from Australia to Honolulu is through a tropical climate permitting rapid development of the fruit fly. No one ever will know just how the pest reached Honolulu on these vessels from Australia, but in view of the rigid inspection service of the Hawaiian Board of Agriculture it seems probable that larvæ falling from infested fruits in the ships' stores—in those days often kept on deck—transformed to the winged adult stage by the time of arrival at Honolulu. From 7 to 10 years ago trees bearing fruits in which the fruit fly could develop grew in greater abundance within a stone's throw of the docks than at the present time and offered an excellent breeding place for stray adults flying from the ships during the time these were in port. There is probably no port in the world where conditions were so favorable for the establishment of this particular pest as was that of Honolulu 10 years ago.

LOSSES INCURRED THROUGH THE FRUIT FLY.

The economic importance of the Mediterranean fruit fly as a pest of fruits varies with the climate of its natural abode, or habitat. Thus, in France, near Paris, where it has been known to attack apricots and peaches, it has not become a serious pest, because of climatic checks. Such checks to the severity of its attacks have been noted in portions of Australia, South Africa, and elsewhere, and would be operative in continental United States except in portions of California and the Southern States. On the other hand, in tropical and semitropical countries the fruit fly is capable of becoming a pest of first importance, and, as in the Hawaiian Islands, may be classed as the most important insect pest to horticultural development.

Practically every fruit crop of value to man is subject to attack by this fruit fly. Not only is it of importance as a destroyer of fruit, but it is the cause of numerous stringent quarantines which cost the State and Federal Governments much money to make effective and which rob countries of good or prospective markets for their fruit. Fortunately, it has been found that the Chinese banana and the pineapple, the two most valuable species of fresh fruits formerly

exported from Hawaii, offer so little danger as carriers of the Mediterranean fruit fly, when they are packed for shipment, that this part of Hawaii's export trade in fresh fruits with the coast may still be carried on, provided the inspections of the Federal Horticultural

Board now in force are continued. The necessary quarantines against all other host fruits, however, particularly against such fruits as the avocado and mango, has had, and will continue to have, a serious effect upon horticultural pursuits and the development of the small farmer.

At present the infestation of edible fruits in the coastal regions of Hawaii is general and about as severe as could be expected. The work of the Mediterranean fruit fly, with that of the melon fly, has put a most serious check upon the horticultural development of the islands just at a time when this development was gathering strength. In South Africa the Mediterranean fruit fly is regarded as one of the greatest drawbacks to the development of the fruit in-



FIG. 4.—Apples destroyed by larvæ of Mediterranean fruit fly. Although an apple externally may appear normal aside from the dark spots where the female fly punctured the skin in laying her eggs, the pulp is often found badly decayed and eaten out by the maggots, as shown in the lower fruit. (Original.)

dustry in Cape Colony, where, it is stated, during certain favorable seasons large areas of apricots, figs, pears, plums, apples (fig. 4), and quinces are almost all affected. Many instances of damage to citrus and other crops in southern Europe, South America, Africa, and Aus-

tralia might be added to impress one unfamiliar with the ravages of this pest that it is one that can not be trifled with. The amount of damage which would result through the introduction of this fruit fly is so great that every effort should be taken to prevent its establishment in new territory.

WHAT THE MEDITERRANEAN FRUIT FLY IS LIKE.

The adults.—The Mediterranean fruit fly is an insect that in the adult stage resembles in size and general shape the ordinary house fly, but differs greatly in the color pattern of the body and wings and in its habits. In figure 5 three adults may be seen attempting to lay eggs in an orange. The glistening black spots upon the insects' back, the two white bands on the yellowish abdomen, and the yellow and black markings of the wings at once distinguish this fruit fly from all other insects in Hawaii. The colors, brown, yellow, black, and white, predominate and form a pattern that can be recognized easily after comparison with the drawing of the adult fly (fig. 1).

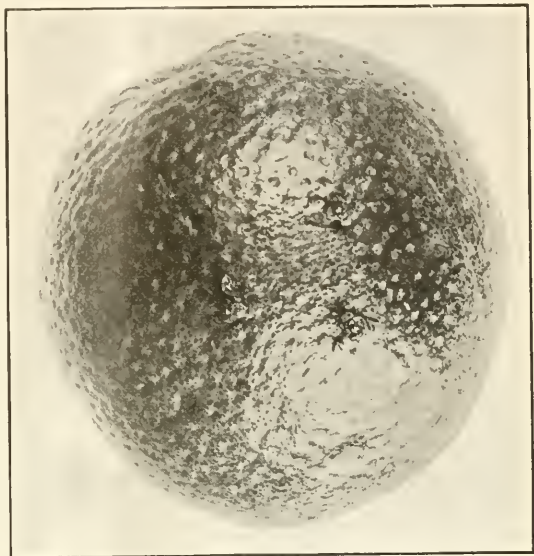


FIG. 5.—Three adults of the Mediterranean fruit fly on a sweet orange. About two-thirds natural size. (Authors' illustration.)

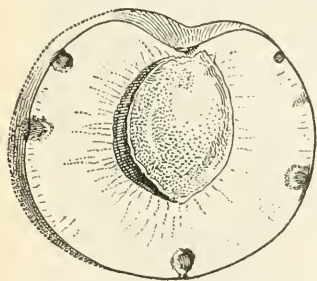


FIG. 6.—Cross section of a small apricot showing eggs laid through skin in five places. (Authors' illustration.)

The eggs.—The female fly is able to drill, with the sharp end of her body, small pinhole-like breaks or punctures in the skin of fruits, and through these punctures she lays her eggs. Naturally, these egg punctures are so small that they are not seen by the average person. Ordinarily the fly lays from one to six eggs through these holes into a small cavity made for them just beneath in the pulp or rind. In

some instances several hundred of the small white eggs, which are only about one-twenty-seventh of an inch long and shaped as those illustrated in figures 6, 7, and 21, may accumulate in a single

egg cavity as the result of repeated egg laying by many females through the same opening in the skin.

The larvæ.—The eggs hatch into whitish larvæ, or maggots, that burrow or tunnel in all directions through the pulp, feeding as they go and causing decays to start. When first hatched they are very difficult to detect, but when full grown they are very white and, although only four-sixteenths to five-sixteenths of an inch long, are quite easily seen. Full-grown maggots have the peculiar habit, if taken out of the fruit and placed upon a smooth surface, of curling up and jumping from 1 to 6 inches. For the general appearance of the larvæ see figures 8 and 9, *a*.

The pupæ.—After leaving the fruit upon which they have fed, the larvæ either burrow into the soil to depths varying up to 2

inches or seek shelter under any object upon the ground and there transform to the pupa or chrysalis stage. During this stage the insect is not able to move and resembles the seedlike object illustrated in figure 9, *b*. Although outwardly appearing quite dead, inwardly the wonderful changes are taking place by means of which nature transforms the ugly maggot into the beautiful fly; and in the course of a few days the adult fly breaks forth from the pupa, pushes her way up through the soil, and, as the mother of a second generation, flies back to the tree and searches for fruits in which to lay her eggs.

INTERESTING FACTS ABOUT THE ADULT FLY.

Incapable of inflicting bodily injury on man, the adult fly is, nevertheless, the fruit growers' most persistent enemy in Hawaii, for she is continuously searching for fruits in which to lay her eggs. Adults die within three to four days if they have

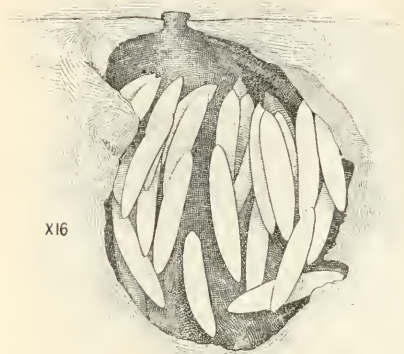


FIG. 7.—Cross section of peach showing general shriveling of walls of egg cavity and separation of eggs. Drawing made one and one-half days after eggs were laid. (Authors' illustration.)



FIG. 8.—Small mango fruit cut to show white larvæ or maggots of Mediterranean fruit fly and damage they have caused. (Severin.)

no food; but if they can secure the juices of fruits or the honeydew of insects, which form the bulk of their food, they may live long periods. Two flies lived for 230 and 315 days, respectively. But as a rule life is much shorter, although many live to be four to six months old. Many die when they are very young, even if they have had food.

In Honolulu females begin to lay eggs when 4 to 10 days old, and, like hens, only much more faithfully, continue to develop and lay eggs in fruits almost daily so long as they live. A female may lay on an average from 4 to 6 eggs a day, 22 eggs being the largest number known to have been laid by a fly during any one day. On 10 consecutive days one fly laid 8, 11, 9, 6, 8, 3, 3, 3, 3, and 9 eggs; another laid 0, 5, 14, 8, 13, 10, 6, 4, 4, and 0 eggs. The largest number of eggs laid during life by a single female kept in the labo-

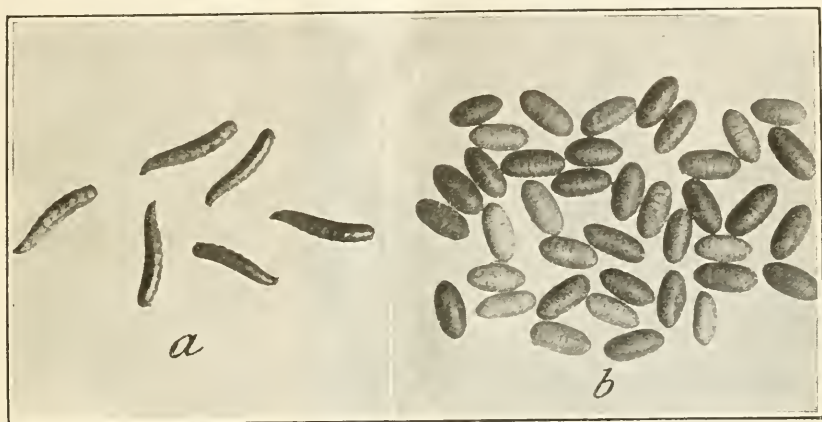


FIG 9.—Mediterranean fruit fly: *a*, Larvæ, or maggots; *b*, pupæ, or chrysalids. Twice natural size. (Original.)

ratory was 622. This fly lived only 153 days. It is probable that 800 eggs, or even more, may be laid by single hardy females under favorable conditions.

It is also important, from the standpoint of control, to know that females deprived of a chance to lay eggs in fruits for a period of four to six months when certain crops are not in season have the power to begin depositing eggs as actively as younger flies when fruits sufficiently ripe become available for oviposition. Thus one female kept in the laboratory for the first five months of her life without fruits in which to lay eggs laid 11, 4, 9, and 9 eggs during the first four days of the sixth month of her life when fruits were placed in the cage with her.

CLIMATIC CONDITIONS FAVORING RAPID INCREASE IN HAWAII.

The time required by the fly to pass through the egg, larva, and pupa stages depends very much upon the climate. The climate of Honolulu and of the coastwise regions of Hawaii in general is very

favorable to fruit-fly increase. At Honolulu the temperature rarely drops as low as 58° F., and then only for a few hours during one or



FIG. 10.—Three important edible fruits subject to fruit-fly attack: *a*, Strawberry guava; *b*, loquat; *c*, star apple. These are grown also for their ornamental value. (Original.)

temperature averages about 79.5° F., the Mediterranean fruit fly requires as few as 17 or as many as 33 days to pass through its immature stages.

two nights in the year. The daily range in temperature is small, averaging between 8 and 11 degrees, while the normal monthly mean temperatures range between 70.9° F. in the winter and 79° F. in the summer. Biological work has shown that even the lowest monthly means of localities up to 1,500 feet elevation have little effect upon the fruit fly other than to retard somewhat its development. It is never cold enough throughout the coastal regions of Hawaii to render either the adults or the larvæ inactive. There are no periods of the year at any Hawaiian port when climatic conditions are unfavorable for fruit-fly increase. A continuous temperature of 58° to 62° F., or the lowest range of temperature usually experienced, does not increase the normal mortality among the larvæ.

LENGTH OF TIME REQUIRED FOR DEVELOPMENT.

During the warmest Hawaiian weather, when the mean tem-

At this season by far the larger number pass through these stages in 18 to 20 days. At an average mean temperature of 68° F., which is about the coolest temperature in Hawaii where fruits are generally grown, the immature stages require 40 to 69 days.

Just what the length of the immature stages may be in cooler regions can not be definitely stated, but experiments indicate that it may be considerably increased. The egg stage has been increased from a normal of 2 days at Honolulu in summer to 25 days by the application for 22 days of a temperature of 48° to 53° F. A well-grown larva survived a temperature of 48° to 54° F. for 79 days. A newly-hatched larva remained practically dormant for 57 days at an out-of-door temperature ranging from 27° to 73° F. (mean 48° F.), whereas in Honolulu during summer it would have remained in this stage only 2 days. The fruit fly has been held in the pupa stage for about two months at an out-of-door temperature ranging between 38° and 72° F. (mean, about 54° F.). Had the mean been about 79° F., it would have remained in the pupa stage only 9 to 11 days. Three larvæ in very firm apples required 28, 58, and 74 days to become full grown and leave the fruit to pupate at Kealahou, where the temperature ranged between 58° and 80° F. (mean, about 68° F.). Add to the 74 days required for larval maturity 4 days for the egg stage and 20 days for the pupa stage, and one has 98 days, or over three months, as the time required for the fly to pass through the immature stages under certain host conditions at a mean of 68° F. Thus while these stages may be completed in as few as 17 days, three to four months is a very conservative estimate for possible length under less favorable climatic conditions, or a period sufficiently long to outlast the coolest seasons of the semitropics.

FRUITS, NUTS, AND VEGETABLES ATTACKED.

The Mediterranean fruit fly is particularly injurious because it attacks so many more different kinds of fruits of value to man than does any other known fruit fly. In the Hawaiian Islands 72 kinds of fruits have been found infested. Fortunately, the pineapple is not infested, and the banana is free from attack when shipped under commercial conditions. The fruit fly has been reared from the following fruits: Fruits that are heavily or generally infested are marked (1), those that serve quite often as hosts or of which many escape infestation are marked (2), and those rarely infested are marked (3).

List of host fruits of the Mediterranean fruit fly.

SCIENTIFIC NAME.	COMMON NAME.
1. <i>Achras sapota</i> (3).....	Sapodilla.
2. <i>Acordia</i> sp. (3).....	Acordia.
3. <i>Anona muricata</i> (2).....	Sour sop.
4. <i>Arengia saccharifera</i> (3).....	Sugar palm.
5. <i>Artocarpus incisa</i> (3).....	Breadfruit.
6. <i>Averrhoa carambola</i> (2).....	Carambola.
7. <i>Calophyllum inophyllum</i> (1).....	Ball kamani.
8. <i>Capsicum</i> sp. (2).....	Bell peppers (fig. 17, p. 19).
9. <i>Carica papaya</i> (2).....	Papaya.
10. <i>Carica quercifolia</i> (2).....	Dwarf papaya.
11. <i>Carissa arduina</i> (2).....	Carissa (fig. 11, <i>h</i>).
12. <i>Casimiroa edulis</i> (1).....	Sapota.
13. <i>Cestrum</i> sp. (3).....	Chinese inkberry.
14. <i>Chrysophyllum cainito</i> (1).....	Star apple (fig. 10, <i>c</i>).
15. <i>Chrysophyllum oliviforme</i> (1).....	Damson plum (fig. 11, <i>d</i>).
16. <i>Chrysophyllum</i> sp. (1).....	Chrysophyllum.
17. <i>Citrus japonica</i> (1).....	Chinese orange (fig. 18, p. 26).
18. <i>Citrus japonica</i> (1).....	Kumquat.
19. <i>Citrus nobilis</i> (1).....	Tangerine.
20. <i>Citrus nobilis</i> (1).....	Mandarin.
21. <i>Citrus medica limetta</i> (1).....	Lime.
22. <i>Citrus medica limonum</i> (1).....	Lemon (fig. 19, p. 21).
23. <i>Citrus decumana</i> (1).....	Grapefruit (figs. 2, 20, 21, 22, pp. 3, 22, and 23).
24. <i>Citrus decumana</i> (1).....	Shaddock.
25. <i>Citrus aurantium</i> (1).....	Sweet orange.
26. <i>Citrus aurantium</i> var. <i>amara</i> (1).....	Sour orange.
27. <i>Clausena vampi</i> (3).....	Wampi.
28. <i>Coffea arabica</i> (1).....	Coffee (fig. 11, <i>b</i>).
29. <i>Coffea liberica</i> (1).....	Liberian coffee.
30. <i>Cydonia vulgaris</i> (1).....	Quince.
31. <i>Diospyros decandra</i> (1).....	Persimmon.
32. <i>Eriobotrya japonica</i> (1).....	Loquat (fig. 10, <i>b</i>).
33. <i>Eugenia brasiliensis</i> (1).....	Brazilian plum or Spanish cherry.
34. <i>Eugenia jambos</i> (1).....	Rose apple (fig. 11, <i>g</i>).
35. <i>Eugenia michelii</i> (1).....	Surinam cherry.
36. <i>Eugenia uniflora</i> (1).....	French cherry.
37. <i>Ficus carica</i> (1).....	Fig.
38. <i>Garcinia mangostana</i> (2).....	Mangosteen.
39. <i>Garcinia xanthochymus</i> (2).....	Mangosteen.
40. <i>Gossypium</i> spp. (2).....	Cultivated cotton (fig. 11, <i>e</i>).
41. <i>Jambosa malaccensis</i> (2).....	Mountain apple.
42. <i>Lantania placuachulla</i> (3).....	Palm.
43. <i>Lycopersicum esculentum</i> (2).....	Tomato.
44. <i>Litchi chinensis</i> (3).....	Lichee nuts (fig. 11, <i>c</i>).
45. <i>Mangifera indica</i> (1).....	Mango (figs. 8, 24, pp. 8 and 25).
46. <i>Mimusops elengi</i> (1).....	Elengi tree (fig. 11, <i>i</i>).
47. <i>Murraya exotica</i> (1).....	Mock orange (fig. 11, <i>f</i>).
48. <i>Musa</i> spp. (3).....	Banana (figs. 14 and 15, p. 17).
49. <i>Noronhia emarginata</i> (3).....	Noronhia.
50. <i>Ochrosia elliptica</i> (2).....	Ochrosia.

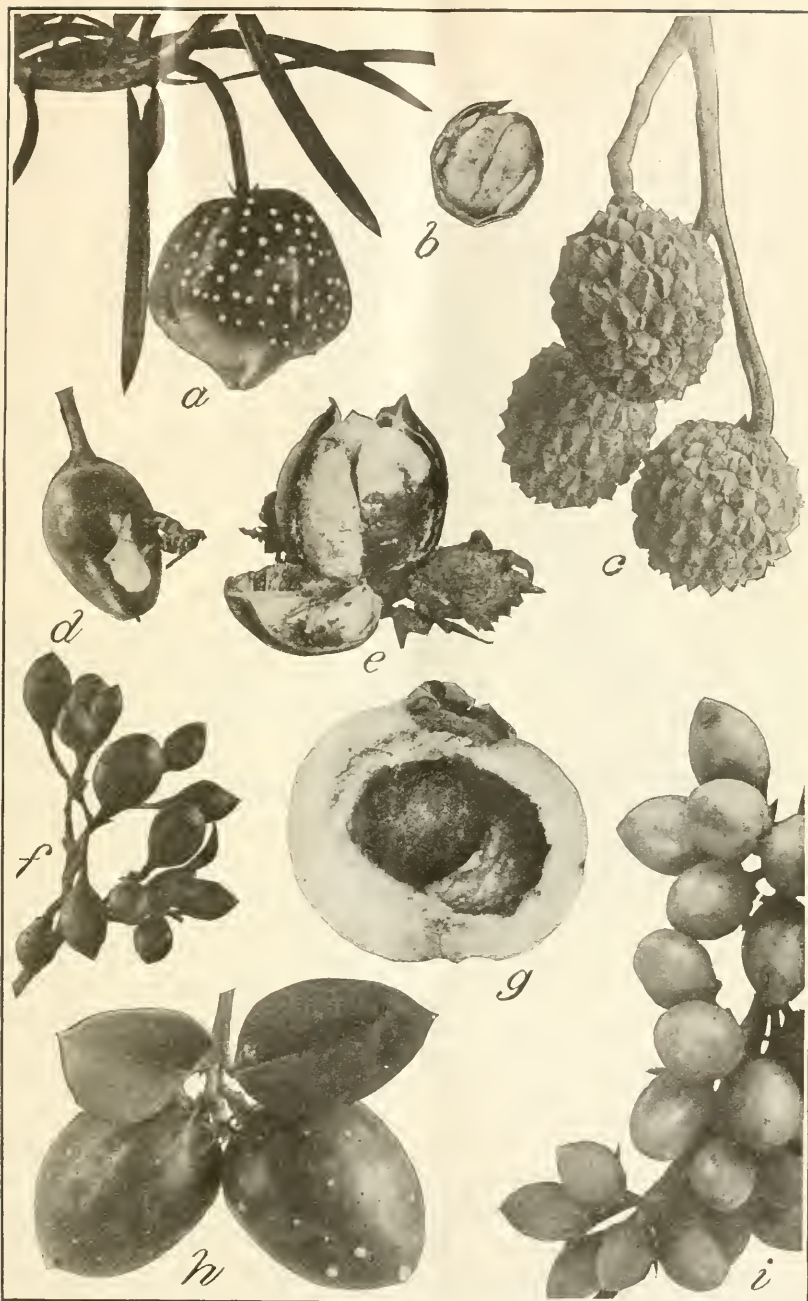


FIG. 11.—Ornamental trees and shrubs grown in Hawaii that support the fruit fly. It is useless to protect edible fruits when ornamentals are allowed to grow near by that harbor the fruit fly: *a*, The bestill, showing drops of white sap that exude when the fly punctures the skin; *b*, a coffee cherry sectioned to show the maggots feeding on the pulp; *c*, the lichee nut is not attacked by the fly unless the outer skin has broken; *d*, a damson plum, showing an adult fly caught in the sticky sap; *e*, a cotton boll infested by the pink bollworm and the fruit fly; *f*, a cluster of mock-orange berries; *g*, a rose apple sectioned to show fruit-fly attack; *h*, the carissa, showing drops of white sap that have exuded from punctures made in the skin by the fruit fly; *i*, the elengi berries, that develop many fruit flies.

51. *Opuntia vulgaris* (2)..... Prickly pear.
52. *Passiflora* sp. (3)..... Passion vine.
53. *Persca gratissima* (2)..... Avocado (fig. 13).
54. *Phoenix dactylifera* (3)..... Date palm.
55. *Psidium cattleianum* (1)..... Strawberry guava (fig. 10, *a*).
56. *Psidium guayava* (1)..... Sweet red and white lemon guavas.
57. *Psidium guayava pomiferum* (1)..... Common guava.
58. *Psidium guayava pyriferum* (3)..... Waiawi.
59. *Prunus persica* (1)..... Peach (fig. 7, p. 8).
60. *Prunus persica* var. *nectarina* (1)..... Nectarine.
61. *Prunus armeniaca* (1)..... Apricot (fig. 6, p. 7).
62. *Prunus* spp. (1)..... Plum.
63. *Punica granatum* (3)..... Pomegranate.
64. *Pyrus* spp. (1)..... Apple (fig. 4, p. 6).
65. *Pyrus* spp. (1)..... Pear (fig. 12).
66. *Solanum melongena* (3)..... Eggplant.
67. *Spondias dulcis* (3)..... Wi.
68. *Terminalia catappa* (1)..... Winged kamani or tropical almond.
69. *Terminalia chebula* (1)..... Natal plum.
70. *Thevetia nerifolia* (1)..... Bestill (fig. 11, *a*).
71. *Vitis labrusca* (3)..... Grape (fig. 25, p. 26).
72. *Santalum freycinetianum* var. *littorale*
 (3)..... Beach sandalwood.

This list shows that practically all the ordinary useful and edible fruits in Hawaii are infested heavily. Thus peaches can not be grown at present, for they are ruined before they become well grown; Chinese oranges (fig. 18), tangerines, figs, loquats (fig. 10, *b*), rose apples (fig. 11, *g*), many varieties of mangoes (figs. 8, 24), certain avocados (fig. 13), guavas (fig. 10, *a*), coffee cherries (fig. 11, *b*), star apples (fig. 10, *c*), sapotas, persimmons, apples (fig. 4), pears (fig. 12), plums, nectarines, and quinces—all these are badly infested. On the other hand, a large percentage of the ripening fruits of the tomato, prickly pear, mangosteens, mountain apples, and wampis are free from attack, although certain fruits may be at times heavily infested. When tomatoes are wormy, the melon fly, and not the Mediterranean fruit fly, is usually the insect doing the damage. Ordinarily, sweet bell peppers are not generally infested, and cotton bolls become infested only after they have been damaged by some other insect (figs. 17 and 11, *e*).

The pomegranate, breadfruit, eggplant, wi, grape (fig. 25), date, certain seeds of palms, lichee nuts (fig. 11, *c*), and the Chinese inkberry are very rarely infested, even in Honolulu. For practical purposes they may be said to be immune. Lichee nuts ripening on the tree become infested only when the outer shell breaks, thus exposing the white pulp to attack.

Hawaiian fruits, nuts, and vegetables not listed are free from attack.

ORNAMENTALS SERVING AS HOSTS.

Not only does the Mediterranean fruit fly attack the ordinary cultivated fruits, but in Hawaii it has shown a preference for the fruits of many ornamental trees and shrubs. Thus the nuts of the winged kamani, the ball kamani, the rose apple, damson plum, star apple, Brazilian plum or Spanish cherry, the Surinam and French cherries, the berries of the mock orange and elengi tree, the fruits of the Natal plum, and the mature fruits of the bestill are all usually well infested. Even the fruits of certain palms and the beach sandalwood may harbor the fly. Ornaments less subject to attack may be found in the foregoing complete list.

HOST FRUITS OF COMMERCIAL VALUE.

PINEAPPLES.

Many experiments have been carried on to determine whether the Mediterranean fruit fly can live in the pineapple. It has been found that even under forced laboratory conditions the fly can not live or mature in green or ripe pineapples. No person has ever found a pineapple infested by this pest in Hawaii.

PAPAYAS.

The papaya is one of the commonest plants about Honolulu. Its fruit is the universal breakfast fruit. Probably not one person in a thousand in Honolulu, however, knows that papayas become infested. Unless the fruits are allowed to remain upon the trees until overripe,



FIG. 12.—Bartlett pear, the pulp of which has been entirely eaten out by the maggots of the Mediterranean fruit fly. The fruits often remain on the tree and shrivel up after they have been ruined. (Authors' illustration.)

the fruit fly can not mature in them. The milky juice, which exudes copiously from breaks in the skin of the fruits up to the time when

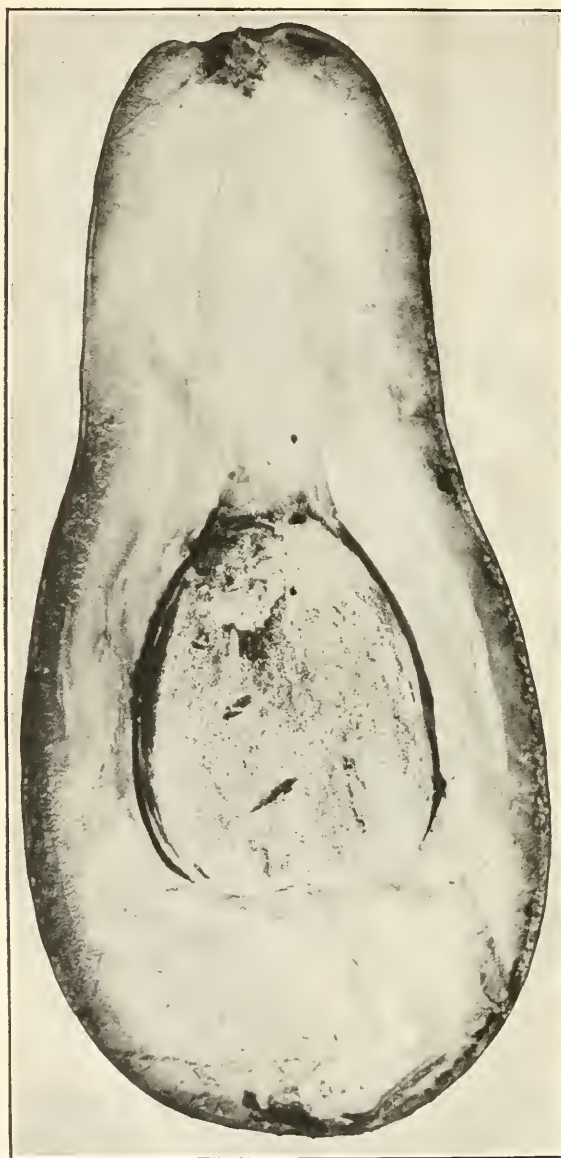


FIG. 13.—Avocado. This valuable fruit of California and Florida is subject to infestation in Hawaii. In this instance the maggots are working at the stem and blossom ends. (Authors' illustration.)

the fruits can be cut for ripening in the house, contains a digestive principle that is fatal to the eggs and larvæ of the fly. This juice protects the fruits from infestation when immature. But as the fruits become overripe, and also unfit for the table, the juice flows less abundantly from breaks in the skin made by the fly when she attempts to lay her eggs, and the eggs which she then lays can mature. As many as 205 flies have been reared from single overripe fruits. So while the papaya is a host fruit, it is practically never infested until too ripe or otherwise unfit for the table.

AVOCADOS.

With the exception of one or two early varieties, the infestation of the avocado is so obscure that the general belief prevails in Honolulu that this fruit is free from attack. The Guate-

malta, or nutmeg, variety is the only one free from attack when growing uninjured. The skin of all other varieties, whether thin or of usual toughness, can be punctured by the adult fly, as proved by many examinations of fruits. The avocado, like the ordinary pear, is best when picked



FIG. 14.—Cooking banana of the Popoulu variety taken from tree in an infested condition. Note small round holes in the skin through which maggots left the fruit when they became full grown. (Authors' illustration.)



FIG. 15.—Cooking banana of the Moa variety cut to show destruction of pulp by maggots of the Mediterranean fruit fly. (Authors' illustration.)

while still hard, though mature, and allowed to soften in storage. With most varieties it is not until the fruits are mature enough for gathering or dropping that adults lay eggs in them. Many fruits upon the market are not in the least affected. While avocados are not usually a favorite host for the fly, they are sufficiently infested to warrant the quarantine prohibiting the shipment of them to the mainland. (See fig. 13.)

BANANAS.

Experimentation during the past four years in Hawaii has proved that the Chinese banana¹ and the Bluefields banana² are practically immune from attack if harvested and shipped to the coast in accordance with the demands of the trade and the Federal Horti-

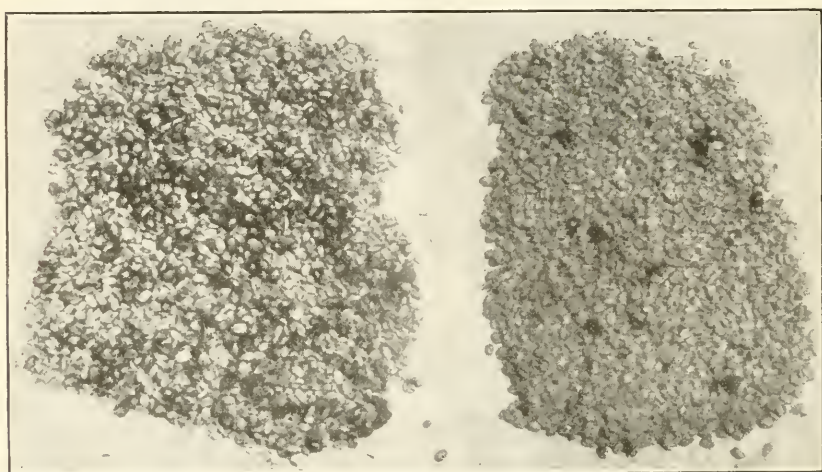


FIG. 16.—Loss to coffee-mill owners due to infestation of coffee cherries by Mediterranean fruit fly. Coffee beans to left pulped from uninfested cherries; beans to right pulped from infested cherries. Cherries failing to pulp, because infested, appear as black; pulped beans are grayish white. (Original.)

cultural Board. Persons wishing the results of careful experimental work used as a basis for these conclusions may obtain them in printed form by applying to the Bureau of Entomology. The immunity of commercial varieties of bananas has been shown to be due to the fact that neither the eggs nor the newly-hatched larvæ can survive in the tannin-laden peel of the green though mature fruit. Indeed, the copious and sudden flow of sap from egg punctures made by the female fly in unripe bananas renders the successful placing of eggs in such fruits difficult and rare.

No fruits of the Chinese variety ripening prematurely on bunches in plantations have been found infested. But of the cooking bananas, flies have been reared from the ripe and yellowish fruits of the thin-skinned Popoulu variety (fig. 14) growing in the field, and from the

¹ *Musa cavendishii*.

² *Musa sapientum*.

well-grown though green-colored fruits of the Moa variety, the peel of which had become cracked, thus causing a break in nature's normal protection to the pulp. Figure 15 is a cross section of a Moa banana, showing the tunnels made through the pulp by the larvæ, and the darkened decayed areas about the tunnels. Adults have been reared also from another variety of cooking bananas.

Because flies have been reared from cooking bananas, it is not considered safe to permit their export to the coast, and they have been placed on the list of quarantined fruits by the Federal Horticultural Board. The Chinese and Blue-fields bananas may still be exported from Hawaii, provided they are grown and inspected before shipment in accordance with Federal regulations. So far as is known, the "apple" and the "ice-cream" bananas common in Hawaii are not infested.

COFFEE.

Coffee cherries as they ripen are favorite hosts of the Mediterranean fruit fly. Fortunately, the larvæ attack only the pulp surrounding the beans or seeds, and in no way affect the value of the latter (see fig. 11, *b*). Chemical analyses of beans from infested and uninfested cherries, tasting tests of coffee made from similar roasted beans, and weighings made of dried beans have failed to reveal any ill effect to the beans themselves due to fruit-fly attack.

The unrestricted development of larvæ within coffee cherries, however, does bring about certain losses to the grower and mill owner. Before parasites were introduced cherries became infested

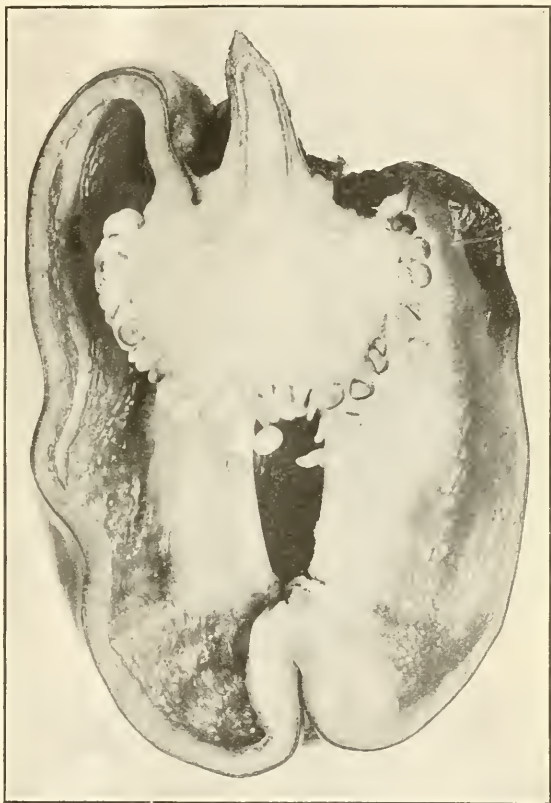


FIG. 17.—Sweet bell pepper infested by Mediterranean fruit-fly larvæ. Note that the upper right-hand portion of fruit has decayed as a result of attack. This decay later extends to all parts of the fruit. (Original.)

as soon as they began to turn white from green in the final ripening process, and the larvæ, numbering from 2 to 8, were able to become nearly full grown by the time the cherries had turned red. The pulp surrounding the beans varies from two to seven fifteenths of an inch in thickness, or is scarcely thicker than the well-grown larva of the fruit fly (see fig. 30, p. 39). Therefore, by the time the cherry is ordinarily ready for harvesting, the larvæ have devoured practically all the pulp, leaving the seeds hanging more or less loosely within a sack comprised of the thin skin of the cherry. If the weather happens to be dry, the skin shrivels and hardens about the beans

and the cherry remains on the branch indefinitely and resembles those killed by disease. However, should the harvesting season be rainy, the skin decays rapidly, and under the weight of the beans the cherry falls to the ground. A slight jar may at such times cause many cherries to fall to the ground, where they are lost. This type of loss necessitates extra pickings and greater cost for labor. Since the successful introduction of parasites the fruit fly has been so reduced in the coffee field that the infestation of

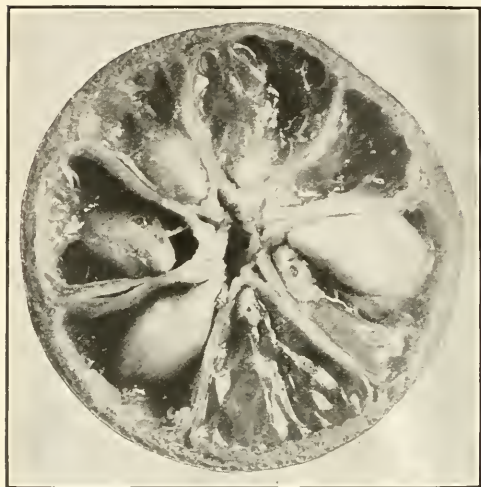


FIG. 18.—Chinese orange sectioned to show damage by Mediterranean fruit fly. Chinese oranges, kumquats, tangerines, satsuma oranges, and many limes are easily and generally infested because of their loose peel and lack of a thick protective rag. (Original.)

cherries occurs so late in the ripening process that extra pickings are not necessary, and the cherries on reaching the pulping mills during the height of the harvesting season contain chiefly eggs or young larvæ which have not had an opportunity to reduce the pulp.

Badly infested cherries do not pulp as readily when run through the pulping mill, and naturally weigh much less than sound cherries. (Fig. 16.) The loss in number of cherries in a given weight of badly infested fruit has been found to vary at times from 27 to 59 per cent. This loss in weight, which takes place only in the worthless pulp, and in no way affects the bean, which alone is of commercial value, brought about a financial loss to growers who sold their fruit by weight according to prices obtained before the fruit fly was intro-

duced. This has been appreciated and has caused a readjustment of prices paid for coffee "in the cherry" and has been responsible for the erection of many small pulping mills throughout the Kona coffee district.

It seems reasonable to believe that the remarkable success of introduced parasites in checking the infestation of coffee will free the coffee grower from further worry so far as the Mediterranean fruit fly is concerned.

CITRUS FRUITS.

While all citrus fruits are favorite hosts of the Mediterranean fruit fly, certain of them are found to contain larvæ more often than others. No citrus fruits are too acid for fruit-fly development. Larvæ have been reared from the sourest lemons. Adult flies are fond of laying eggs in large numbers in all citrus fruits. Thus 13 punctures in one grapefruit contained 76, 153, 32, 25, 18, 8, 46, 113, and 9 eggs, respectively. Thirty-nine oranges, either yellow or orange in color, contained an average of 32 egg punctures, with a maximum of 108 and a minimum of 7 punctures. In 50 ripe lemons 1,422 eggs were laid in 185 punctures. Yet no adult flies developed from this grapefruit or from the oranges and lemons. On the other hand, well ripened Chinese oranges (fig. 18), thin-skinned limes, kumquats, and tangerines are so generally infested with larvæ in the pulp before they become well ripened that they are always regarded with suspicion.

Although many eggs are laid in lemons, it is rare that lemons are found with maggots in the pulp even when the fruits are so ripe

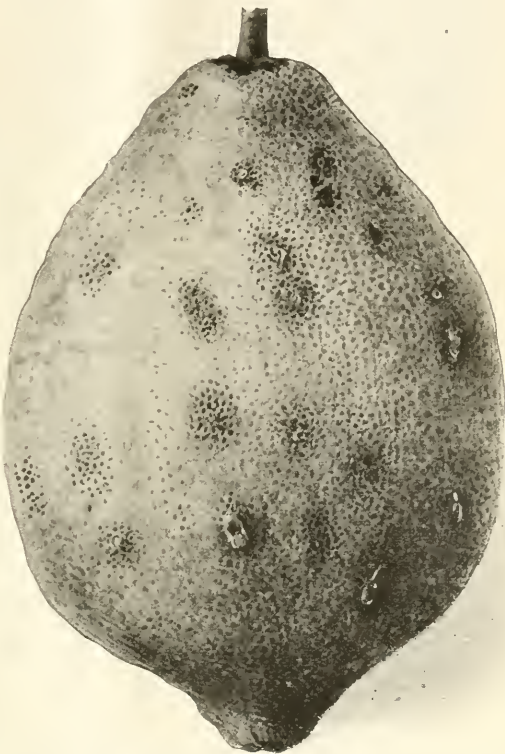


FIG. 19.—Lemons of commercial varieties have never been found with larvæ of the Mediterranean fruit fly destroying the pulp unless they have had the rind cut or broken previous to attack. The adult flies may puncture the skin and lay eggs, as indicated by the discolored spots, but the eggs and larvæ die in the peel. (Original.)



FIG. 20.—Ripe grapefruit showing copious gummy secretions that may, though more often do not, follow attack by Mediterranean fruit fly. (Original.)

Chinese oranges the peel is so thin that the fruit fly can lay her eggs through it into the pulp itself or between the pulp and the rind, so that the larvæ on hatching can at once begin to feed on the pulp. As a result the pulp of the Chinese orange (fig. 18) is almost always infested with larvæ. The case is different with lemons (fig. 19), grapefruit (fig. 20), and ordinary seedling oranges. In these fruits the peel is so thick that the fly must deposit her eggs in the outer part of the white rag as illustrated in figure 21. In making the puncture she often ruptures an oil cell in the rind, and the oil thus liberated kills the eggs. But if the eggs are laid between oil cells, the young larvæ have difficulty in making their way through the rag to the pulp, and a very high percentage of them die in the attempt.

Then, too, a gall-like hardening develops quite rapidly about the egg cavity in oranges, grapefruit, and lemons, as indicated by the darkened area about the egg cavity in figure 21. This hardening often makes of the cavity a prison from which the young larvæ can not escape and in which they are literally starved to death.

It thus happens that the larvæ that succeed in entering the rag of the peel from the egg cavity are able to reach the pulp of grapefruit

that they fall to the ground. Why, then, are Chinese oranges and tangerines easily infested with larvæ in the pulp whereas lemons, grapefruit, and oranges ward off fatal attack either entirely or until after they are overripe?

The reason is that a great mortality occurs among the eggs and newly hatched larvæ in citrus fruits having a thick peeling or rind. In Chi-

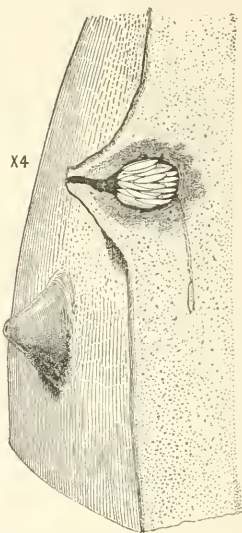


FIG. 21.—Section of grapefruit rind, showing two egg cavities, one in cross section. Drawing made one week after fruit was picked. Note conical elevation about egg cavities left by withering of rind; also thickened walls of egg cavity and single larval channel in therag. (Authors' illustration.)

and oranges in astonishingly small numbers because of the imperviousness of the rag. It is the persistent attack of successive families of larvæ hatching from different batches of eggs laid in the same punctures that finally breaks down the barrier between the young larvæ and the pulp. A fuller discussion of the infestation of all citrus fruits may be had on application to the Bureau of Entomology.

Regardless of what has just been stated concerning the great mortality that occurs among the eggs and young larvæ in the rind



FIG. 22.—Cross section of grapefruit to indicate difficulty of always telling from exterior appearance of a fruit that maggots are eating out the pulp. (Authors' illustration.)

of grapefruit, oranges, and lemons, adult flies have been reared from them all. Lemons, however, have never been known to be infested in the pulp unless the rind has first become broken by thorn pricks, decays, or in some other mechanical manner. And in spite of the fact that oranges and grapefruit may become very wormy, as illustrated in figures 2 and 22, they are usually uninfested in the pulp, and are fit for table use if they are gathered as soon as they ripen. But if citrus fruits were grown commercially in Hawaii in large

orchards as they are in Florida and California, and were severely attacked as they are in Hawaii to-day, they could not be shipped profitably, for, although they might not contain larvæ within the pulp, the many breaks in the rind made by the flies while laying eggs would make possible the entry of various molds (see fig. 23) that



FIG. 23.—Orange injured by Mediterranean fruit fly. Each black spot represents a place where the fruit fly has punctured the rind to lay eggs, but the maggots were not able to eat through the peel, and died. About the injured spot decays have started which at first affect only the peel. Blue mold grows rapidly in these injured spots. (Original.)

would cause unprecedented decays while the shipments were en route to market.

ARTIFICIAL METHODS OF CONTROL NOT SATISFACTORY UNDER HAWAIIAN CONDITIONS.

It is unfortunate that the satisfactory methods of control used against the Mediterranean fruit fly in several other countries, particularly in portions of South Africa and Australia, have failed in Hawaii. There are, however, several good reasons for such failures. The great money-making crops of Hawaii at present are sugar, pineapples, rice, coffee, taro, bananas, and cattle. But sugar, pineapples, and taro are not attacked by this fruit fly, and, as already shown, coffee and bananas are not sufficiently attacked to injure their commercial value. With one exception, including a small number of

avocados, no commercial orchards exist in Hawaii. Still there is hardly a family, unless it be in the business section of Honolulu, that does not grow a number of fruit trees, such as oranges, lemons, papayas, peaches, avocados, limes, grapefruit, guavas, bananas, mangoes, etc., that bear prodigally under normal Hawaiian cultural conditions, and, until the advent of the fruit fly in 1910, formed a most welcome addition to the food supply.

Much of the native-grown fruit that is sold in the local market is grown on trees scattered here and there in dooryards and is in excess of what the owner needs. Practically no one depends on growing fruit for his living. No developed fruit industry exists such as one finds on the mainland, and no moneyed interest concerns itself with steps for fruit-fly eradication. In other words, there are no impelling incentives to solidify public opinion for the consistent and cooperative use of artificial remedial measures that could be made effective if their application would yield returns warranting the expenditure.

The situation also is made more difficult by reason of the large amount of vegetation, bearing fruits of little or no value to man, that grows throughout the islands and that can not be eradicated without the expenditure of prohibitive sums of money.

But this great abundance of dooryard and wild host vegetation has had such a vital part in the undoing of artificial control measures and in the success of parasite introductions that it is worthy of further attention. Aided by a favorable climate, it has made of Hawaii a fruit-fly paradise that is not duplicated elsewhere on the earth.



FIG. 24.—Improved mango sectioned to show havoc caused by maggots of Mediterranean fruit fly. (Authors' illustration.)

THE CAMPAIGN AGAINST THE FRUIT FLY IN HAWAII.

HOST CONDITIONS IN HONOLULU AND HILO.

The residents of Honolulu and Hilo are justly proud of their magnificent vegetation and have taken great pleasure in growing an



FIG. 25.—This bunch of grapes, apparently perfect, contains one berry that is decayed and contains a larva of the Mediterranean fruit fly. The Isabella grapes in Hawaii are seldom attacked, even in Honolulu, yet they are likely to carry the fly to California. (Original.)

unusually large assortment of trees and shrubs on their properties. An inventory of such trees and shrubs in the portion of Honolulu bounded by Liliha, Punchbowl, Beretania, and School Streets gave a total of 4,610 that bore fruits in which the fruit fly can develop.

TABLE II.—*Number and species of host trees of the Mediterranean fruit fly growing in that portion of Honolulu bounded by Liliha, Punchbowl, Beretania, and School Streets.*

Apricot.....	1	Mandarin.....	28
Avocado.....	653	Mango.....	1, 154
Breadfruit.....	58	Mangosteen.....	7
Carambola.....	48	Mountain apple.....	41
Chinese inkberry.....	6	Mock orange.....	33
Chinese orange.....	148	Orange, sweet.....	372
Coffee.....	298	Papaya.....	687
Coffee, Liberian.....	8	Peach.....	69
Cotton.....	11	Pear, Bartlett.....	2
Custard apple.....	1	Pomegranate.....	128
Damson plum.....	4	Pomelo.....	15
Fig.....	201	Rose apple.....	25
Guava, common.....	94	Sapodilla.....	5
Guava, strawberry.....	73	Sapota.....	30
Java plum.....	80	Sour sop.....	57
Kamani, ball.....	4	Spanish cherry.....	1
Kamani, winged.....	13	Star apple.....	4
Kumquat.....	4	Surinam cherry.....	63
Lemon.....	22	Wi.....	19
Lichee.....	40	Waiawi.....	60
Lime.....	10		
Loquat.....	33	Total.....	4, 610

In this area of 60 blocks of varying size, 712 dooryards, or estates, averaged 6.5 host trees or shrubs.

In Hilo, island of Hawaii, host conditions are quite as favorable for fruit-fly increase as in Honolulu. Thus the following numbers of host trees and shrubs were found in certain yards during March, 1914.

YARD 1.		YARD 2—Continued.	
Rose apple.....	1	Orange.....	2
Surinam cherry.....	4	Strawberry guava.....	2
Japanese plum.....	2	Coffee.....	14
Mountain apple.....	6	Bananas.....	
Star apple.....	1	Avocado.....	2
Coffee trees.....	34	Peach.....	1
Common guava.....	20	Fig.....	3
Brazilian banana.....	15	Mountain apple.....	2
Avocado.....	4	Lichee nut.....	2
Mango.....	3	Common guava.....	3
Papaya.....	2		
Orange.....	5	YARD 3.	
Peach.....	1	Rose apple.....	11
Grape.....	1	Mango.....	2
Winged kamani.....	1	Thevetia.....	3
Mangosteen.....	1	Avocado.....	1
Fig.....	1		
Mimusops.....	1	YARD 4.	
YARD 2.		Peach.....	4
Surinam cherry.....	2	Mango.....	6
Papaya.....	2	Loquat.....	1
Thevetia.....	1	Winged kamani.....	3
		Surinam cherry.....	2
		Strawberry guava.....	1

The great variety of host vegetation which ripens its fruit at different seasons leaves no time in Hawaii when fruits are entirely out of season. The fact that certain hosts, such as the Chinese orange, Surinam cherry, and mock orange, bear several crops a year and others, such as specimens of the ball and the winged kamanis and the bestill, appear to be seldom entirely free from ripening fruits, assure food for the fruit fly the year round. The succession of fruits also is increased by the individuality of trees of the same species, or even of certain branches of a single tree, which results in a very uneven ripening of the fruit. While the data in Table III do not indicate the seasonal abundance of host fruits, they have been summarized from the collections of clean-culture inspections during 1913 to show the remarkable succession of host fruits ripening in greater or less abundance throughout the year in Honolulu. The presence of so much ripening fruit, much of it on tall trees such as those illustrated in figures 26, 27, and 28, has made it possible for the fruit fly to multiply with unprecedented rapidity and thwart artificial remedial measures.

TABLE III.—*Data indicating the seasons of the year when inspectors of the clean-culture campaign collected various fruits infested by the Mediterranean fruit fly.*¹

Fruit.	Jan. 1-11.	Jan. 13-18.	Jan. 20-25.	Jan. 27-Feb. 1.	Feb. 3-8.	Feb. 10-15.	Feb. 17-22.	Feb. 24-Mar. 1.	Mar. 3-8.	Mar. 10-15.	Mar. 17-22.	Mar. 24-29.	Mar. 31-Apr. 5.	Apr. 7-12.	Apr. 14-19.	Apr. 21-26.	Apr. 28-May 3.
Avocado.....	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x
Carambola.....	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x
Chinese orange.....	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x
Chrysophyllum spp.....	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x
Coffee.....	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x
Damson plum.....	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x
Surinam cherry.....	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x
Fig.....	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x
Grapefruit.....	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x
Guava.....	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x
Kamani, ball.....	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x
Kumquat.....	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x
Lime.....	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x
Loquat.....	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x
Mango.....	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x
Mock orange.....	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x
Mountain apple.....	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x
Orange.....	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x
Papaya.....	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x
Peach.....	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x
Pepper.....	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x
Prickly pear.....	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x
Rose apple.....	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x
Star apple.....	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x
Bestill.....	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x
Sour sop.....	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x
Mandarin.....	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x
Lemon.....	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x
Kamani, winged.....	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x
Spanish cherry.....	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x
Bartlett pear.....	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x

¹ This table is not intended to indicate the seasonal abundance of host fruits.

HOST CONDITIONS IN THE COUNTRY.

While host conditions within the city limits render useless such artificial control measures as can be applied under existing conditions, country host conditions are almost, if not quite, as discouraging. Here the fruit fly has been able to establish itself, often miles from towns, in some one or more of its hosts which have escaped cultivation and have spread over uncultivated and uncultivable areas. Of such hosts, the common guava is the most abundant. It has taken possession of the roadsides, pastures (as shown in fig. 26), vacant town lots, mountain gulches and hillsides, and even crevices on precipices. So easily does the plant grow from seed and so thoroughly distributed are its seeds by cattle, birds, and man,



FIG. 26.—Men cutting down a dense thicket of guava bushes. In such a guava scrub ripening fruits are present throughout the entire year and in them the Mediterranean fruit fly breeds, often far from cultivated fields. (Authors' illustration.)

that it is seldom that in the lowlands, except in very arid areas, a bush can not be found within a stone's throw. In pastures and mountain gulches up to an elevation of at least 1,500 feet, particularly where sheltered from strong winds and well watered, the guavas may become very treelike and form dense thickets. While the guava fruits most heavily during the spring and fall months, the bushes are continuously in bloom and ripen a sufficient number of fruits to support the fruit fly every month in the year.

Second to the guava as a host occurring in the wild uncultivated areas is the prickly-pear cactus. Though the fruits of this plant are not preferred by the fruit fly, they are sufficiently infested in the absence of more favored hosts to serve as food, and, as in the case of the guava, there is almost no time during the year when a few ripe fruits can not be found in any cactus scrub.

Other host fruits, wild or escaped, are not so generally distributed. As a few of the many examples, there may be mentioned a grove of ball kamani trees in an isolated valley on the Island of Molokai, gulches overgrown with the passion vine and the damson plum on the island of Maui, the thickets of winged kamani growing along the windward shores of the island of Oahu, and the wild coffee in the forests of Oahu and Hawaii.

In addition to the wild fruits in country places, the fruit fly finds strongholds in the many, and often isolated, native home sites scattered throughout the coastal region. About these may be growing the mango, rose apple, orange, peach, ball and winged kamanis, etc. The Kona district of Hawaii has large areas containing thousands of acres of coffee under cultivation in which the fruit fly finds food at all seasons of the year, because of the uneven ripening of the crops due to the varying altitudes at which coffee is grown.

CLEAN CULTURE A FAILURE IN HAWAII.

Clean culture in its broadest sense includes not only the detection, collection, and destruction of all infested fruits, but also the elimination of useless or unnecessary host vegetation. In some one or all of its phases it has been recommended and practiced in every country where the fruit fly is a pest, but in nearly all of these the apparent indifference displayed by the majority of the people, no matter how much they may have lamented their losses, has rendered clean culture inefficient.

The clean-culture campaign instituted by the Hawaiian board of agriculture during the fall of 1911 and continued by the Federal Bureau of Entomology from October, 1912, until April, 1914, was a failure from the very start in that it did not protect fruits from attack. There were minor contributory causes, but the main reason for failure was the insurmountable difficulties placed in the way of success by territorial legislation, adverse host and climatic conditions, and the lack of any commercially grown crop worth protecting. This method of control proved hopeless after the first few months' trial from the standpoint of alleviating the Hawaiian situation, and while the destruction of fruit was encouraged, in the absence of a better plan for lessening the opportunities for spread of the pest to the coast by means of infested fruits carried on board ships sailing from Honolulu, it has since been discontinued.

It is doubtful if any clean-culture campaign against the fruit fly has ever been organized so efficiently or on so large a scale as was that organized by the Hawaiian board to include Honolulu. That this method should prove a failure under Hawaiian conditions is no reflection upon the ability of those directly in charge of the work. The law prohibited inspectors from gathering and destroying the

fruits unless they could first prove to the satisfaction of the property holders that each fruit was infested. This restriction placed upon the activity of the inspectors led to numerous difficulties between inspectors and those opposed to clean culture. This law also prohibited a systematic gathering of all host fruits within a given area, thus necessitating many examinations for the removal, as they ripened, of the fruits of each single tree. As fruits ripen rapidly in the semitropics, it proved a physical impossibility to arrange visits of inspectors frequently enough to prevent infested fruits from falling to the ground.

The data of Tables II and III demonstrate the immense number and diversity of host trees and shrubs in Honolulu and the ease with



FIG. 27.—Ball kamani trees grown for shade and ornament. This tree grows to a large size, and sometimes in dense thickets in the forest. Its fruits ripen at all seasons of the year and are badly infested by the Mediterranean fruit fly. (Authors' illustration.)

which the fruit fly, uncurbed by climatic conditions, finds fruit for egg laying during any day of the year. It is absurd to endeavor to remove all the fruit from many of the huge trees of the islands. There are numerous large trees (figs. 27, 28) beneath which infested fruits may be gathered each week in the year, yet the trees are so tall and brittle that no inspector can remove the fruits before they ripen. One yard in Hilo has 15 host trees from 20 to 50 feet high. To these examples might be added many others in which the removal of fruits is equally impracticable. Often the fruits of the star apple, for instance, ripening in the tops of tall trees do not fall until long after they have shriveled up and until after the many larvæ developing within have matured and dropped from them to the ground. One

acre of guava or of coffee can support the fly throughout the year without the aid of other host fruits and form a center for the reinfestation of surrounding areas. Notwithstanding the fact that the bulk of the ripening and infested fruits can be collected except during the mango season, lasting from May to July, and fruit-fly conditions unquestionably improved from the standpoint of the numerical abundance of adult flies, the important fact remains that the number of fruit flies that succeed in reaching maturity is sufficiently large to infest practically every fruit ripening within the city.

Clean culture can not be made effective under present conditions. The islands are thoroughly overrun with the fruit fly, and this applies



FIG. 28.—The fruits of this tree, the winged kamani, ripening throughout the year, are badly infested by the Mediterranean fruit fly. The nuts of this one tree are enough to supply adult flies for an entire neighborhood. (Authors' illustration.)

quite as much to the guava scrubs in pastures or lava flows and in mountain gulches as within city limits. By far the larger proportion of the host trees and shrubs are grown more for protection from the tropic sun and for their ornamental value than for their fruits. Large numbers of the host fruits are not edible. The destruction of host vegetation is out of the question until it can be proved that some worth-while advantage can be gained. To cut down all host trees in Honolulu at present would mean the removal of a large percentage of her prized vegetation without giving her citizens any adequate compensation.

VALUE OF ELIMINATING HOST VEGETATION.

In Honolulu many mango and orange trees were either cut down or severely trimmed, but those cut formed too small a percentage of the entire host vegetation to serve a practical purpose. The only places where the elimination of host vegetation yielded favorable results were about banana and pineapple plantations where the work was done in accordance with the regulations of the Federal Horticultural Board. In these instances the destruction of vegetation did not eliminate the adult flies, for these came in from surrounding areas. It did, however, lessen the danger of immature stages becoming attached to the packing material of bananas and pineapples shipped to the mainland.

Should the Mediterranean fruit fly ever become established in California or the Southern States, however, where there is no such wealth of native host fruits and where climatic conditions will prove an important factor in control, the elimination of host vegetation will play a most valuable part in remedial measures. In Algeria the infestation of oranges greatly increased after such crops as peaches and persimmons were grown. These fruits furnished food for the fly during the summer and early fall months, which were for the fly starvation months previous to the cultivation of these crops. Aided by these summer crops, the fruit fly was able to increase greatly, so that when the orange crop began to ripen during the fall and winter months the pest could attack it with increased force. In Bermuda the elimination of a comparatively few host trees, numerically speaking, would mean the elimination of breeding places for considerable areas. The destruction of unnecessary and valueless host trees will not only restrict the breeding ground, but will often so break up the sequence of ripening hosts that many adult flies will die while attempting to bridge the starvation periods when no fruits can be found for egg laying.

DESTRUCTION OF INFESTED FRUITS AND SPRAYING.

The destruction of infested fruits and spraying are remedial measures that should go hand in hand. In Honolulu they have not given satisfactory results for reasons beyond the control of man, as set forth on pages 24 to 33. Nevertheless, they can be made successful in commercial orchards, if applied with intelligence and persistence throughout a neighborhood. One indifferent neighbor can spoil the work carried on in surrounding orchards. A community of growers must determine in what crop their interests are centered and impartially eliminate nonessential fruits. Then, and, as a rule, not until then, will labor spent on the destruction of infested fruits and

on spraying prove worth while. Sprays are applied to kill the adults; fruits are destroyed to kill the eggs and contained larvæ.

DESTRUCTION OF INFESTED FRUITS.

Larvæ infesting fruits may be killed by submerging the fruits in water or by burying, boiling, or burning the fruits. The choice of method will depend largely upon the quantity of fruit to be handled and upon local conditions. The surest way to kill all immature stages of the fruit fly is to boil or burn the fruits. Burning the fruits is often expensive and, when trash in compost holes is depended upon to furnish the fuel, the burning operation is likely to be unsatisfactory; for in Honolulu, at least, the amount of fruit to burn is so greatly in excess of the trash that the work is incompletely done. Bringing infested fruits to the boiling point will kill all forms of the fruit fly. Submerging fruits in ordinary cold water for five days will either kill all larvæ and eggs or prevent their further development.

Burial in soil is a satisfactory method, provided the fruit is buried deep enough and afterwards cracks are prevented from developing in the earth above the fruits as the latter decay and settle. It should be remembered that just after transforming from the pupa the adults are so soft that they have the remarkable ability to force their way through incredibly small openings. Hence, a crack in the soil extending down to the fruit, even though it be no wider than the thickness of ordinary blotting paper, is wide enough to permit the adults to reach the surface and so thwart the purpose of fruit burial. Adults can not make their way through 1 foot of well-tamped soil, but because burial or burning is left to subordinates, who may slight the work, boiling or submergence of fruit in water is more highly recommended.

SPRAYING.

As adult flies can not lay eggs until 4 to 10 days after they emerge from the pupa, anything that will kill them during this period is useful. Such a remedy has been found in poisoned-bait sprays. These are composed of a sweet substance attractive to the flies, a poison, and water. Mally, who first used a poisoned spray in controlling this pest, used a formula containing: Sugar, 3 pounds; arsenate of lead, 4 ounces; water, 5 gallons. This he applied at the rate of 1 to 1½ pints to each 10-year-old peach or nectarine tree. Lounsbury used 6 pounds of brown sugar, 6 ounces of arsenate of lead paste, and 8 gallons of water. Severin used the Mally formula but increased the poison to 5 ounces. Weinland used 3½ ounces of arsenate of lead, 10 pounds of brown sugar, 5 gallons of plantation molasses, and 50 gallons of water. All of these formulas have proved to be efficacious.

Attempts to control the Mediterranean fruit fly under Honolulu conditions were unsuccessful. The number of adults killed was great, yet a sufficient number survived to infest all fruits that ripened. From what is known, however, of the benefits derived from these sprays in other countries, there is no question but that poisoned-bait sprays, when intelligently applied under such commercial conditions as exist in California and Florida, will prove successful. Thus Mally in South Africa states that a "severe outbreak of the pest in a commercial peach orchard was brought to a sudden and practically complete halt, and the fruit maturing later was marked under the guarantee of freedom from maggots," while the infestation among fruits on check trees increased until all fruits became infested. Newman in Western Australia estimates the cost of spraying an acre when one application of one pint of spray per tree is made every 12 to 14 days to be from \$1.50 to \$2 per fortnight, and states that this sum is a mere bagatelle to the loss of fruit during a similar period over a like area. Both Mally and Newman, working under conditions of less rainfall than obtained at Honolulu, and more like those of California and of fall and winter in Florida, believe that good results will follow the consistent application of poisoned bait sprays, particularly when supplemented by the proper destruction of infested fruits.

Honeybees are not endangered by the application of poisoned-bait sprays.

COLD-STORAGE TEMPERATURES.

Cold-storage temperatures do not lessen the damage already done fruits by larvæ within them, but they may become of inestimable value in guarding fruits against further attacks while in storage or transit and in freeing them from suspicion as carriers of the fruit fly.

For the details of the effect of cold-storage temperatures upon eggs, larvæ, and pupæ of the Mediterranean fruit fly, application should be made to the Bureau of Entomology for articles already published. Fruits of almost any variety commonly held in storage are held at temperatures varying from 32° to 45° F., with preference shown to a range of 32° to 36° F. It may be said that no immature stages of the Mediterranean fruit fly can survive refrigeration for seven weeks at 40° to 45° F., for three weeks at 33° to 40° F., or for two weeks at 32° to 33° F.

It seems reasonable to conclude that sooner or later the certification of properly refrigerated fruit will be practicable. When an association of fruit growers, or a people, find it financially worth while, there is no reason why they can not operate a central refrigeration plant under the supervision of an official whose reputation shall be sufficient to guarantee all fruits sent out from the plant to be absolutely free from danger as carriers of the fruit fly.

PROTECTIVE COVERINGS.

The only certain method now known of protecting fruit from fruit-fly attack in Hawaii is to cover them, when still very green, with some type of covering through which the fly can not lay her eggs. In many places ordinary cheesecloth sewed into bags, large enough to be slipped over the tree and tied about the trunk, have been used. These have been tried in Honolulu, but difficulty was experienced in putting the bags on soon enough and in making certain that no adult female flies were inclosed during the process. Considering the cost of material and the real danger of inclosing flies, the impossibility of covering many trees, and the breakage due to winds, this method of protection is not recommended.

The protection of the fruit on individual branches with coverings of cloth or paper is entirely feasible and very popular in Hawaii. Individual fruits inclosed in ordinary paper bags (fig. 29) are well and cheaply protected. Coverings of cheesecloth for separate fruits are not as good as paper, for the fruit fly can lay her eggs through certain coarser-woven kinds after the cloth has become matted against the fruit by rains.

Orange and small mango trees with their fruits inclosed in paper bags are often seen in Honolulu. Though this method of covering each fruit gives protection, it involves much labor and patience, and its practicability can be determined only by the value placed upon the fruit by the owner. So severe, however, is fruit-fly attack in Hawaii that this method, or some one of its many modified forms, must be used if fruits are to be brought to maturity uninfested.



FIG. 29.—Quince fruit protected from fruit-fly attack by a paper bag. The bag is slipped over the fruit while it is still quite green. Although this method of protection is not practical on a large scale, it is used much in Hawaii for the protection of dooryard or experimental fruits. (Original.)

NATURAL CONTROL OF THE FRUIT FLY.

No striking examples of control by natural agencies were evident in Hawaii previous to the introduction of parasites. Larvæ are killed in large numbers within fruits which are permitted to remain on the

ground exposed to the direct sunlight in summer, but many larvæ escape even from such fruits. An examination of 17 mangoes exposed over sand on shallow trays to the sun for two days in August revealed 17 living and 98 dead well-grown larvæ in the fruit, and 103 that succeeded in safely leaving the fruit to form pupæ in the sand beneath. The small brown ant,¹ so common about the lowlands of Hawaii, unquestionably is a factor in natural control. It is frequently found swarming over and in fallen fruits and kills many larvæ as they leave the fruits to pupate. Ants were observed to remove from a fallen ball kamani nut 86 medium-sized larvæ during a 40-minute period, but they failed to reach 34 other larvæ in a firmer portion of the fruit.

No natural checks upon fruit-fly increase in Hawaii, aside from introduced parasites, are of practical value; but in many other lands climatic checks are unquestionably of great value, and, as in many places in Spain, for instance, are the only checks that make fruit production possible without the use of remedial measures.

CLIMATIC CHECKS.

Observations made in various countries indicate that the Mediterranean fruit fly will not be a serious pest when the monthly mean temperature falls to or below 50° F. for from three to four consecutive months during the year. In Hawaii the climate is not cold enough throughout the fruit-growing regions to act as a serious check on fruit-fly increase. Development progresses most rapidly after the Hawaiian means reach 75° to 79° F. At a mean of 68° F. development requires about twice the time. A temperature of 58° to 62° F. may increase the period of development to three to four times the normal period for the warmest weather. Larval development in apples stored outdoors at temperatures ranging from 31° to 64° F. (mean, about 51° F.) was slow and was attended by no unusual mortality. No development occurred at 26° to 70° F. (mean, 48° F.), and nearly all larvæ were dead at the end of six weeks. Very few fruit flies can develop at 49° to 50° F., and none at temperatures below this point. Complete mortality will follow continued exposure to temperatures below 50° F. An exposure for two to three weeks at 32° F. will kill all stages of the fruit fly, but an exposure to this low temperature for four days has practically no effect upon the fly. Sixty-two of 248 larvæ survived an exposure for five days to 21° to 28° F. These facts indicate that the Mediterranean fruit fly is a very hardy and persistent enemy in spite of the quickness with which it responds to checks upon its development resulting from the low temperatures ordinarily experienced in semitropical countries.

¹ *Pheidole megacephala* Fab.

PARASITES.

The very climatic and host conditions that have made the Mediterranean fruit fly an unusually serious pest in Hawaii and that, with crop conditions as they are, have made artificial methods of control impracticable, have been most favorable for an attempt at control by means of parasites. An abundance of the fruit fly upon which to feed and a climate permitting increase each month in the year have made conditions ideal. The search for and discovery of parasites, and their introduction and establishment where previously there had been none, has been one of the entomological romances of the present time. The parasites now at work killing the fruit fly in Hawaii have been introduced by the Hawaiian Board of Agriculture and Forestry as a result of the Silvestri and the Fullaway-Bridwell expeditions to Africa.

These two expeditions resulted in the establishment in the islands between May, 1913, and October, 1914, of four promising parasites: one from South Africa,¹ one from eastern Australia,² and two from Nigeria,³ West Africa. Of these, only one, the South African *Opius*, was discovered as a

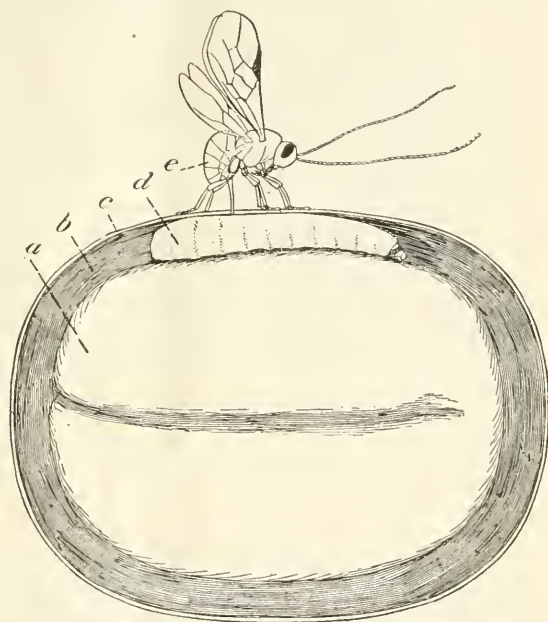


FIG. 30.—Diagrammatic drawing of a cross section of a coffee cherry to illustrate comparative ease with which the South African parasite can lay eggs in the fruit-fly larva: *a*, Coffee bean; *b*, pulp destroyed by maggot; *c*, skin of cherry; *d*, maggot of fruit fly; *e*, parasite forcing its stinger through skin of cherry into maggot. (Original.)

parasite of the Mediterranean fruit fly. The three others were found parasitizing other fruit flies, and they have adapted themselves in Hawaii to the Mediterranean fruit fly. None of them, however, has been known to attack the melon fly in the gardens in Hawaii. Large numbers of all the parasites have been reared and have been liberated in all parts of the islands, until to-day they are well able to care for themselves. They have multiplied with remarkable rapidity and have unquestionably reduced the numerical

¹ *Opius humilis* Silv. ² *Diachasma tryoni* Cam. ³ *D. fullawayi* Silv. and *Tetrastichus giffardianus* Silv.

abundance of the fruit fly. To-day no batch of infested fruit can be collected from which fruit-fly parasites can not be reared.

Only a beginning has been made in determining the effectiveness of parasites as a control factor against the fruit fly in Hawaii. The rapidity of establishment and the increase of the parasites have been very gratifying, yet the data already published recording the percentages of parasitism during the years 1914, 1915, and 1916 indicate that while parasitism in thin-meated fruits, such as coffee (see (fig. 30), may be consistently very high, in thicker fruits, like the orange, it is consistently very low. Thus the parasitism among larvæ developing in coffee may range between 90 and 100 per cent, while that among larvæ of the Chinese orange is more likely to range from almost nothing to 30 per cent. High parasitism among larvæ in such fruits as coffee is due to the fact that the larvæ are within reach of the parasite. On the other hand, the larvæ within such fruits as the orange may feed about the seeds and therefore remain safe from attack so long as they stay at the core, and are subject to attacks only when they come to the surface of the fruit.

Since adult fruit flies can live many months and lay eggs quite regularly, they have been able, with the aid of the unprecedented variety and abundance of host fruits in Hawaii, thus far to keep such an ascendancy over their parasites that they cause the infestation of practically all fruits ripening. It would appear that unless effective pupal and egg parasites are introduced, or more care is given to the elimination of host fruits which more thoroughly protect the larvæ from parasite attack, or to the planting of fruits which make possible the reproduction of large numbers of parasites, little practical value will result from the work of the parasites from the standpoint of rendering host fruits free from attack.

Though it seems evident that the favored host fruits will always be well infested if present cultural conditions continue, it is hoped that the efficiency of the parasites may be sufficiently enhanced to free from attack such fruits as the avocado and the better varieties of mangoes. In Kona, Hawaii, where the percentage of parasitism in coffee cherries (see fig. 30) has been phenomenally high for three years, it has not been high enough to free more than an occasional cherry from attack. The control exerted by parasites has, however, effected a benefit to coffee growers which probably already has repaid the Territory of Hawaii for all money expended in the introduction of parasites.

The general effectiveness of control by parasites can be increased best by the discovery and introduction of a good egg parasite.

QUARANTINE MEASURES TO PREVENT INTRODUCTION.

To prevent the Mediterranean fruit fly from becoming established in the mainland of the United States, the Federal Horticultural Board has promulgated Quarantine No. 13, which provides that its agents,



FIG. 31.—Chinese laborers inspecting bananas. Each bunch of bananas exported from Hawaii to California is inspected for bruised, cracked, or suspicious looking fruits. (Original.)

both in Hawaii and at the mainland ports of entry, shall have strict supervision over the movements of all fruits permitted entry to the mainland from Hawaii. Quarantine No. 13 makes it unlawful for a



FIG. 32.—Inspecting bananas as they are unloaded on the docks at San Francisco: Inspector making certain that each bunch bears an inspection tag and has been wrapped in material permitted by law. (Photo by Maskew.)

person to ship or carry any fruit from the Hawaiian Islands except ordinary eating bananas, pineapples, taro, and coconuts, and these will not be passed by inspectors at ports of entry, such as San Francisco, Los Angeles, or Seattle, unless they have been inspected by the

Federal agents in Hawaii and bear a Federal certificate of inspection. (Fig. 31.)

In Hawaii every precaution is taken to have bananas and pineapples grown under conditions that will prevent spread of the fruit fly. Plantations, packing sheds, and packing materials are inspected sufficiently often to insure their being in keeping with the regulations of the Federal Board. No fruit can be lawfully accepted for transportation to the mainland by any transporting company in Hawaii until it has been inspected and passed and permits for its acceptance have been issued to the transporting company by agents of the Board. Furthermore, no fruit can be lawfully removed from ships at ports of entry at the mainland unless the permit issued the transporting company in Hawaii is found attached to the bill of lading by the

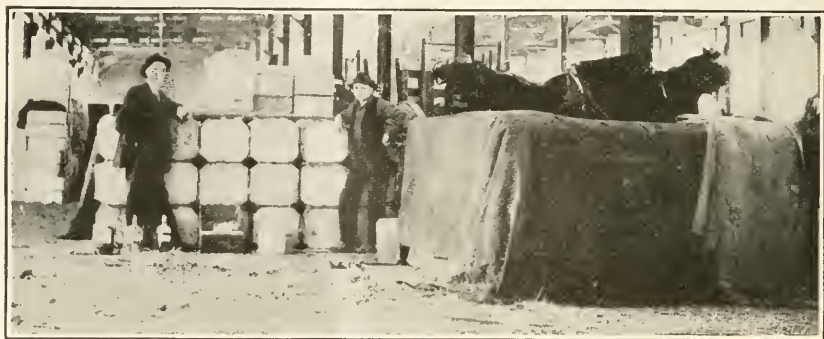


FIG. 33.—Pineapples never breed fruit flies in Hawaii. To be doubly certain that the packing material contains no fruit-fly pupae, all crates of pineapples unloaded on the docks at San Francisco are fumigated with gas after tarpaulins have been thrown over the crates to prevent the gas from escaping. (Photo by Maskew.)

Federal agent, and unless each package or crate of fruit bears the inspection tag above referred to. (Figs. 32 and 33.)

Passengers and ships are permitted to take on board in Hawaii fruits of all descriptions for consumption while en route to the coast. All contraband fruits, however, must be eaten or destroyed before the ship comes within the 3-mile limit of the mainland. Otherwise the transporting company, or the individual passenger, whichever is the offender, is subject to fine or imprisonment, or both.

SUMMARY.

The Mediterranean fruit fly has become so thoroughly entrenched in Hawaii as a result of favorable climatic and host conditions that artificial remedial measures for its control are not practicable. Introduced parasites have multiplied wonderfully well and already have proved of practical value in safeguarding the coffee crop from losses due to fruit-fly attack. Though it is certain that the parasites can

never exterminate the fruit fly or cause the raising of the quarantine against Hawaiian fruits, much ultimate good is expected of them. It is hoped that by lessening the abundance of the fruit fly many fruits that now become badly infested before they are ripe enough to eat may be able to mature uninfested to a point where they will be useful to man. At present almost all edible fruits in Hawaii, and many ornamentals, making a total of 72 kinds of fruit, are subject to attack.

Judging from the past history of the Mediterranean fruit fly, only the vigilance of quarantine officials and the hearty cooperation of travelers will prevent its establishment in California and the Gulf States. Every barrier possible has been erected by State and Federal quarantines, so that there is now little danger of the pest gaining entry through the medium of commercial shipments of fresh fruits. But quarantine officials have found the pest in fruit concealed by tourists and in mail and express packages sent from infested countries by uninformed persons, and it is by such avenues that the pest is most likely to be introduced. These avenues, also, are the most difficult of detection, and their closing is dependent mainly upon educational campaigns to convince the public of the necessity of quarantine measures, and upon the unselfishness and personal honesty of travelers. At present only bananas, pineapples, taro, coconuts, and certain other vegetable products not subject to attack, are permitted entry from Hawaii, and these only after the regulations of the Federal Horticultural Board have been fulfilled.

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UNITED STATES DEPARTMENT OF AGRICULTURE



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FARM PRACTICE IN THE PRODUCTION OF HAY IN STEUBEN COUNTY, N. Y., AND WASHINGTON COUNTY, PA.

(A detailed study of the amount of labor required per acre and per ton for each operation, and the machinery charges per acre and per ton.)

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OBJECT AND SCOPE.

Since hay is very susceptible to damage by bad weather at harvest time, and often demands attention when other farm work is pressing, the problem of getting haying done with a minimum expenditure of time and labor is of great importance to the hay grower. The object of this bulletin is to present data that may help the farmer in solving this problem.

The figures on labor and other factors of production given in the following pages were obtained in a study of hay production made in 1915 on 52 farms in Steuben County, N. Y., and on 37 farms in Washington County, Pa. The methods used by hay growers are practically the same for both of these sections, so that results for each operation are comparable.¹

FACTS BROUGHT OUT.

The total items of production, including labor, machinery charges, interest on hay land, taxes, and seed, averaged \$5 per ton for the New York area and \$6.10 for the Pennsylvania area, with an average yield of about one and a half tons per acre.

¹ Acknowledgment is due to Mr. Robert W. Meyer for valuable assistance in the collection of the data discussed in this bulletin.

It was found that the amount of man labor required to produce a ton of hay averaged 4.2 hours for the 52 farms studied in the New York and 5.23 hours for the 37 farms in the Pennsylvania area. The number of hours of horse labor is almost the same as the number of man hours, 4.22 per ton for New York and 5 for Pennsylvania.

About 36 per cent of all hay produced on the New York farms was sold, while but 17 per cent from the Pennsylvania area reached the market.

The average life of hay meadows was 3.66 years for the New York farms and 4.10 years for the Pennsylvania farms.

The average farm value of hay on December 1 for a period of 10 years (1906-1915) was \$14.62 per ton for the New York farms and \$15.14 for the Pennsylvania farms. With a yield of about one and a half tons per acre, there is an excess over cost of production of \$9.62 per ton for the New York farms and \$9.04 per ton for the Pennsylvania farms in the farm value of No. 1 hay, which indicates that under average conditions hay growing is a profitable farm enterprise in these areas.

DESCRIPTION OF AREAS STUDIED.

Steuben County, N. Y., is one of the more important hay-producing counties in the State. It ranks among the first 10 in total production, both of timothy alone and timothy and clover mixed hay.

In general the surface in this county is very uneven, being broken by a series of long, rather steep hills and moderately broad valleys. The important towns in most cases are connected by good pike roads, which are a great asset in marketing farm crops.

In Washington County, Pa., the hills are of slightly less elevation than those in the New York area, though the slopes are steeper. In the main, however, the topography is the same with reference to facility for making hay.

SIZE OF FARMS.

The average size of the farms studied in Pennsylvania was 171 acres; of the New York farms, 202 acres. (See Table II.) The tillable area per farm is about the same in each State, approximately 156 acres. On the New York farms 35 per cent of the tillable area is in hay, as compared to 26 per cent on the Pennsylvania farms. There is no apparent reason for this large difference in hay area. Washington County is close to the Pittsburgh market, where there is a constant demand for hay, while the hay from Steuben County must be shipped much farther to market—to Buffalo or New York City.

Table I, compiled from census figures (1910 report), gives statistics on the per cent of land in hay for both counties. The per cent of tillable area in hay for each county as a whole is lower than that for the farms where the records were taken. (Compare with Table II.)

TABLE I.—*Per cent of farm land in hay and amount of hay produced.*

(From 13th Census Report, 1910.)

Item	Steuben County, N. Y.	Washington County, Pa.	Item.	Steuben County, N. Y.	Washington County, Pa.
Land in farms (acres).....	818,373	503,923	Per cent of improved land in tame and cultivated hay ...	30.8	20.2
Improved land in farms (acres).....	599,303	432,001	Timothy alone.....	14.1	11.8
Per cent of farm land improved.....	73.2	85.6	Timothy and clover, mixed.....	16.1	5.0
Per cent of farm land in tame and cultivated hay.....	22.5	17.3	Production (in tons):		
Timothy alone.....	10.3	12.7	Tame and cultivated hay.....	184,767	87,292
Timothy and clover, mixed.....	11.7	4.3	Timothy alone.....	84,362	64,014
			Timothy and clover, mixed.....	96,405	21,404

TABLE II.—*Size of farm and per cent of land in hay.*

Item.	52 farms in Steuben County, N. Y.	37 farms in Washington County, Pa.
Average size of farm (acres).....	202.00	171.00
Tillable area (acres).....	157.40	156.00
Per cent of farm land tillable.....	77.9	90.8
Land in hay (acres):		
Per cent of total farm land.....	27.2	24.1
Per cent of tillable land.....	35.2	26.5

AMOUNT OF HAY SOLD.

Four-fifths of the farms studied in the New York area and two-thirds of those studied in the Pennsylvania area sell more or less hay. As shown in Table III, almost half of the hay grown on the New York farms that sold hay is marketed, while only about one-third is sold by the Pennsylvania farms that grew for the market.

TABLE III.—*Amount of hay grown for market.*

Item.	Steuben County, N. Y.	Washington County, Pa.
Number of farms studied.....	52	37
Number of farms that sell hay.....	43	21
Per cent of hay sold by farms selling hay.....	44	50

LABOR RATE.

On these farms labor is usually at a premium during harvest time. In both regions the season in which first-class hay can be made is limited to about 10 working days. On nearly all of the farms in each section the farm owner works in the hay field, and in this study the owners' labor has been given the same value as that of hired help. The man-labor rate has been fixed at 20 cents an hour, which is what the farmer has to pay during the hay-making season. By assuming a single rate for all man labor and not allowing a higher rate for the

owner (though the latter, of course, is also a manager), the results obtained show the average labor requirements for each operation. Horse labor is fixed at 13 cents an hour.

LABOR CHARGES FOR DIFFERENT OPERATIONS.

SEEDING.

On all the farms studied it is customary either to sow timothy in the fall on wheat with clover following in the spring or to sow both in the spring with oats, using the grain drill. There is no charge for horse labor used, for when seeding is not done by the drill with grain it is done by hand, either broadcast or by the use of a mechanical seeder, and the seed is sufficiently covered by the spring thaw.

In the New York area wheelbarrow seeders are used on 17 out of the 52 farms and "hand" seeders on 13 farms. The other 22 farms sow grass seed and clover in the grain drill with oats. In Pennsylvania 11 farms use hand seeders and the rest seed broadcast by hand. (See Table IV.)

About the same amount of work can be done per day with each method of hand seeding, the average being 16.80 acres for the New York farms and 15.50 acres for the Pennsylvania farms. A man can seed by hand between $1\frac{1}{2}$ and $1\frac{3}{4}$ acres per hour. The cost of labor for seeding, spread over the life of the meadow, is 2 cents per ton per year in each State. There is a slight variation in the average life of the meadows.

TABLE IV.—*Cost of hand seeding.*

Item.	52 farms in Steuben County, N. Y.	37 farms in Washington County, Pa.
Number seeding by hand.....	30	37
Average life of meadow, including years used for pasture (years).....	3.66	4.10
Seeded by hand (acres).....	1,411	1,411
Tons produced.....	2,116	2,201
Hours of man labor:		
Per day.....	9.43	10.0
Per acre.....	.561	.643
Per ton.....	.374	.412
Amount seeded:		
Per day (acres).....	16.80	15.54
	(25.20 tons)	(24.24 tons)
Per hour (acres).....	1.76	1.55
	(2.67 tons)	(2.42 tons)
Cost of man labor (at 20 cents per hour):		
Per day.....	\$1.88	\$2.00
Per acre.....	.122	.128
Per hour.....	.075	.082
Cost per year during life of meadow and pasture:		
Per acre.....	.030	.031
Per ton.....	.020	.020

AMOUNT OF SEED GROWN.

The New York farmers visited sow 2.23 pounds less of timothy and 0.62 pound more of clover seed per acre than do the Pennsylvania farmers. The initial cost of seed is practically the same in

both areas, averaging in 1915 about \$2.15 per acre and \$1.41 per ton for the first crop of hay. (See Table V.)

The average life of the meadow, including years used for pasture, is 0.68 year longer for the Pennsylvania farms than for the New York farms. The cost of seed per ton per year of meadow life is 7 cents less for the Pennsylvania group than for the New York group.

The yield per acre has an important bearing on the seed cost per ton of hay. In the New York area, for example, where the lowest yield found on an individual farm was 1 ton per acre, and the highest 3 tons per acre, the seed cost per ton of hay is \$0.62 for the 1-ton-per-acre farm, while the seed cost for the 3-ton-per-acre farm is only \$0.20.

TABLE V.—*Cost of seed and amount sown in 1915.*

Item.	52 farms in Steuben County, N. Y.	37 farms in Washing- ton County, Pa.
Amount of timothy sown, per acre:		
Pounds.....	8.27	10.50
Quarts.....	5.88	7.47
Cost of timothy seed, per acre, at \$3.40 per bushel.....	\$0.625	\$0.793
Amount of clover sown, per acre:		
Pounds.....	9.71	9.09
Quarts.....	5.19	4.85
Cost of seed, per acre, at \$9.25 per bushel.....	\$1.496	\$1.481
Cost of timothy and clover seed, per acre.....	\$2.121	\$2.194
Cost of seed per year during life of meadow:		
Per acre.....	\$0.620	\$0.535
Per ton.....	.414	.343

MOWING.

In the New York area the 5-foot mower is used almost exclusively. Only a few 6-foot mowers and no 7-foot mowers are used. In the Pennsylvania area the 6-foot mower predominates, though a few 7-foot machines are used. The hay cut per hour, however, is about the same for each State, averaging 1 ton. The acreage grown per farm in the New York group is about two-thirds more than the average per farm in the Pennsylvania group. In Pennsylvania, while a larger mower is used, the fields are smaller, which necessitates more waste time in mowing. Another factor that would tend to decrease the amount mowed per hour in Pennsylvania is that the surface is more broken. The hills are steeper in general than in New York, where the topography is more gently sloping. The cost per ton for labor for mowing is about 28 cents in each case. (See Table VI.)

TABLE VI.—*Cost of mowing.*

Item.	52 farms in Steuben County, N. Y.	37 farms in Washington County, Pa.
Amount produced per year (tons).....	<i>a</i> 4,047	<i>b</i> 2,201
Yield per acre (tons).....	1.50	1.56
Width of mower (feet).....	5.14	5.92
Man labor:		
Hay mowed per day (tons).....	<i>c</i> 13.410	<i>d</i> 16.400
Hay mowed per hour (tons).....	<i>e</i> 1,604	<i>f</i> 1,685
Hours of labor—		
Per day.....	8.36	9.73
Per acre.....	.935	.925
Per ton.....	.622	.593
Cost of man labor, at 20 cents per hour—		
Per day.....	\$1.67	\$1.94
Per acre.....	\$0.187	\$0.185
Per ton.....	\$0.124	\$0.118
Horse labor:		
Hours of labor—		
Per day.....	16.72	19.46
Per acre.....	1.870	1.850
Per ton.....	1.246	1.186
Cost of horse labor, at 13 cents per hour—		
Per day.....	\$2.17	\$2.53
Per acre.....	.243	.240
Per ton.....	.162	.154
Cost of man and horse labor:		
Per day.....	\$3.84	\$4.47
Per acre.....	.430	.425
Per ton.....	.286	.272

a 2,698 acres. *b* 1,411 acres. *c* 8,940 acres. *d* 10,510 acres. *e* 1,070 acres. *f* 1,080 acres.

TEDDING.

The tedder is used on over half of the farms in both States. The acreage teded per hour averages 1.62 acres for the New York group and 1.28 for the Pennsylvania group. The average width of tedders used on the New York farms is 1.9 feet more than the average for those used by the Pennsylvania farms, which would account for the fact that 0.3 acre more work is done per hour in New York than in Pennsylvania. (See Table VII.)

The acreage of hay actually teded per year is probably less than the figures would indicate, for when weather conditions are favorable it is not necessary to ted all of the hay unless the crop is heavy. On the farms using tedders, however, it was assumed in this study that all hay was teded. The cost per ton for tedding is 19 cents for the New York group and 23 cents for the Pennsylvania group.

TABLE VII.—*Cost of tedding.*

Item.	52 farms in Steuben County, N. Y.	37 farms in Washington County, Pa.
Number of farms using tedder.....	29	21
Amount teded per year (total tons).....	<i>a</i> 2,191	<i>b</i> 1,444
Yield per acre (tons).....	1.50	1.56
Width of tedder (feet).....	8.76	6.85
Man labor:		
Hay teded per day (tons).....	<i>c</i> 18.10	<i>d</i> 19.75
Hay teded per hour (tons).....	<i>e</i> 2.43	<i>f</i> 1.99
Hours of labor—		
Per day.....	7.45	9.90
Per acre.....	.617	.782
Per ton.....	.441	.501

a 1,461 acres. *b* 926 acres. *c* 12.07 acres. *d* 12.66 acres. *e* 1.62 acres. *f* 1.28 acres

TABLE VII.—*Cost of tedding*—Continued.

Item.	52 farms in Steuben County, N. Y.	37 farms in Washington County, Pa.
Man labor—Continued.		
Cost of man labor, at 20 cents per hour—		
Per day.....	\$1.49	\$1.98
Per acre.....	.123	.156
Per ton.....	.082	.100
Horse labor:		
Hours of labor—		
Per day.....	14.90	19.80
Per acre.....	1.234	1.560
Per ton.....	.822	1.001
Cost of horse labor, at 13 cents per hour—		
Per day.....	\$1.93	\$2.57
Per acre.....	.160	.202
Per ton.....	.107	.130
Cost of man and horse labor:		
Per day.....	\$3.42	\$4.55
Per acre.....	.283	.358
Per ton.....	.189	.230

RAKING.

The common two-horse dump rake is generally used by the farmers of both groups. Both the side-delivery rake and side-delivery tedder are used to a certain extent. Neither bunching nor gleaning is practiced, except by a few farmers. (See Table VIII.)

Wider rakes, by 0.18 foot, are used in the New York farms than on the Pennsylvania farms. The amount of hay raked per hour is about 2.3 acres for New York and 2.0 acres for Pennsylvania. The cost of labor per ton for raking is 13 cents for New York and 15 cents for Pennsylvania.

The cost of raking is one factor in haymaking costs that can sometimes be reduced materially by using a boy to operate the rake.

TABLE VIII.—*Cost of raking.*

Item.	52 farms in Steuben County, N. Y.	37 farms in Washington County, Pa.
Number of farms using rake.....	52	37
Yield per acre (tons).....	1.50	1.56
Width of rake (feet).....	10.83	10.65
Man labor:		
Hay raked per day (tons).....	^a 25.95	^b 24.42
Hay raked per hour (tons).....	^c 3.442	^d 3.010
Hours of labor—		
Per day.....	7.54	8.11
Per acre.....	.436	.518
Per ton.....	.290	.332
Cost of man labor, at 20 cents per hour—		
Per day.....	\$1.51	\$1.62
Per acre.....	.087	.103
Per ton.....	.058	.066
Horse labor:		
Hours of labor—		
Per day.....	15.08	16.22
Per acre.....	.872	1.036
Per ton.....	.580	.664
Cost of horse labor, at 13 cents per hour—		
Per day.....	\$1.96	\$2.10
Per acre.....	.113	.134
Per ton.....	.075	.085
Cost of man and horse labor:		
Per day.....	\$3.47	\$3.72
Per acre.....	.200	.237
Per ton.....	.133	.151

^a 17.30 acres.^b 15.65 acres.^c 2.295 acres.^d 1.930 acres.

LOADING, HAULING, AND PUTTING HAY INTO THE BARN.

The crew most generally used in the New York area is one of four men and two horses. On the 52 New York farms there were found 30 four-man crews, 13 three-man crews, 7 two-man crews, 1 eight-man crew, and 1 six-man crew. Small crews do not as a rule keep any horse or team at the barn, the team used for hauling being also used for hoisting. (See figs. 1 and 2.)

In the cases of about half of the four-man crews one man remains at the barn to drive the team on the hay fork while unloading, and does nothing at other times. In such cases the fourth man is usually an old man or boy unable to work at loading. The four-man arrangement allows two men to work in the mow, enough to put the hay away in good shape.



FIG. 1.—Hay loader in operation. The loader saves time and puts hay on the wagon more cheaply than it can be pitched by hand.

When six, seven, or more men are used, there is a barn crew of from three to four who do all of the unloading, the driver unhitching from the load when reaching the barn and taking an empty wagon back to the field. The two-man crew allows one man to work in the mow and one to stick the hay fork and drive the hoisting team.

In the Pennsylvania area there were found 4 four-man crews, 27 three-man crews, 1 two-man crew, 3 seven-man crews, and 2 six-man crews. (See Table IX.)

The amount of hay handled per crew per hour is about 1.50 tons for the New York group and 1 for the Pennsylvania group, at a cost of 69 cents and 96 cents, respectively.



FIG. 2.—Unloading hay at the barn with horse power. This method is much more rapid than unloading by hand, and horses do the hard part of the work.

TABLE IX.—*Cost of bringing hay from the field and putting into barn.*

Item.	52 farms in Steuben County, N. Y.	37 farms in Washing- ton County, Pa.
Amount produced per year (tons).....	a 4,047	b 2,201
Yield per acre (tons).....	1.50	1.56
Average number of men in crew.....	3.66	3.57
Man labor:		
Hay handled per day (tons).....	c 11.970	d 9.375
Hay handled per hour (tons).....	e 1.480	f 1.080
Hours of labor per day.....	8.09	8.67
Man hours—		
Per day.....	29.65	31.86
Per acre.....	3.715	5.300
Per ton.....	2.475	3.400
Cost of man labor, at 20 cents per hour—		
Per day.....	\$5.93	\$6.37
Per acre.....	.743	1.060
Per ton.....	.495	.680
Horse labor:		
Average number of horses used.....	2.23	2.27
Hours of horse labor—		
Per day.....	18.17	20.11
Per acre.....	2.275	3.346
Per ton.....	1.516	2.145
Cost of horse labor, at 13 cents per hour—		
Per day.....	\$2.36	\$2.61
Per acre.....	.295	.435
Per ton.....	.197	.279
Cost of man and horse labor:		
Per day.....	\$8.29	\$8.98
Per acre.....	1.038	1.495
Per ton.....	.692	.950
a 2,968 acres.	c 7,980 acres.	e 0.968 acre.
b 1,411 acres.	d 6,010 acres.	f 0.693 acre.

LENGTH OF WORKING DAY AND WORK ACCOMPLISHED.

The hours of labor and amount of work done for each of the haying operations on the farms studied is shown in Table X.

TABLE X.—Hours of work per day and amount accomplished in hay-making operations.

Operation.	52 farms in Steuben County, N. Y.					37 farms in Washington County, Pa.				
	Farms reporting each operation.	Hours worked per day per man.	Hours worked per day per horse.	Amount of hay handled per day.		Farms reporting each operation.	Hours worked per day per man.	Hours worked per day per horse.	Amount of hay handled per day.	
				Aeres.	Tons.				Aeres.	Tons.
Seeding by hand.....	30	9.43	-----	16.80	-----	37	10.00	-----	15.54	-----
Mowing.....	52	8.36	16.72	8.94	13.41	37	9.73	19.46	10.51	16.40
Tedding.....	29	7.45	14.90	12.07	18.10	21	9.90	19.80	12.66	19.75
Raking.....	52	7.54	15.08	17.30	25.95	37	8.11	16.22	15.65	24.42
Loading, hauling, and putting into barn.....	52	8.09	18.17	7.98	11.97	37	8.67	20.11	6.01	9.37

WORK ACCOMPLISHED PER HOUR.

The work accomplished per hour, under average conditions, is shown in Table XI. For all farms studied the average per hour for seeding is 1.66 acres; for mowing, 1.07 acres; for tedding, 1.45 acres; for raking, 2.65 acres; and for loading, hauling, and putting into the barn, 3.61 tons. The operation of loading, hauling, and putting into barn is performed by three men or four men, depending upon the length of haul and the adaptability and efficiency of the men.

Table XI may be of some assistance to those who wish to make plans for harvesting hay, acreage and length of working day being known:

TABLE XI.—Amount of hay handled per hour.

Operation.	52 farms in Steuben County, N. Y.						37 farms in Washington County, Pa.					
	Farms reporting each operation.	Width (feet).	Number of men.	Number of horses.	Acres.	Tons.	Farms reporting each operation.	Width (feet).	Number of men.	Number of horses.	Acres.	Tons.
Seeding.....	30	-----	1	-----	1.780	-----	37	-----	1	-----	1.550	-----
Mowing.....	52	5.14	1	2	1.070	1.604	37	5.92	1	2	1.080	1.685
Tedding.....	29	8.76	1	2	1.620	2.430	21	6.85	1	2	1.280	1.990
Raking.....	52	10.83	1	2	2.295	3.442	37	10.65	1	2	1.930	3.010
Loading, hauling, and putting into barn.....	52	-----	3.66	2.23	.968	1.480	37	-----	3.57	2.27	.693	1.080

AMOUNT OF LABOR REQUIRED PER ACRE AND PER TON.

The amount of labor required per acre and per ton on the farms studied is shown in Table XII:

TABLE XII.—*Labor required per acre and per ton for different operations.*

MEN.

Operation.	52 farms in Steuben County, N. Y.				37 farms in Washington County, Pa.			
	Farms reporting each operation.	Number of men.	Man-hours.		Farms reporting each operation.	Number of men.	Man-hours.	
			Per acre.	Per ton.			Per acre.	Per ton.
Seeding by hand ^a	30	1	0.561	.....	37	1	0.643	.....
Mowing.....	52	1	.935	0.622	37	1	.925	0.593
Tedding.....	29	1	.617	.441	21	1	.782	.501
Raking.....	52	1	.436	.290	37	1	.518	.332
Loading, unloading and putting into barn.....	52	3.66	3.715	2.475	37	3.57	5.300	3.400
Total.....			6.264	4.202			8.168	5.238

^a Actual amount of labor required to seed an acre and not prorated for life of meadow.

HORSES.

Operation.	Farms reporting each operation.	Number of horses.	Horse-hours.		Farms reporting each operation.	Number of horses.	Horse-hours.	
			Per acre.	Per ton.			Per acre.	Per ton.
Mowing.....	52	2	1.870	1.246	37	2	1.850	1.186
Tedding.....	29	2	1.234	.882	21	2	1.560	1.001
Raking.....	52	2	.872	.580	37	2	1.036	.664
Loading, unloading, and putting into barn.....	52	2.23	2.275	1.516	37	2.27	3.346	2.145
Total.....			6.251	4.224			7.792	4.996

COMPARISON OF LABOR COSTS FOR DIFFERENT OPERATIONS.

The cost of man and horse labor for the different operations is shown in Table XIII. The total labor cost per ton for the New York group is \$1.31, and for the Pennsylvania group, \$1.63. The difference in cost is due almost entirely to the cost of loading, hauling, and putting into the barn, which is 32 cents higher in Pennsylvania than in New York. The costs for other operations show only very slight differences.

TABLE XIII.—*Cost of man labor and of horse labor per acre and per ton for different operations.*

MAN LABOR.

Operation.	52 farms in Steuben County, N. Y.			37 farms in Washington County, Pa.		
	Farms.	Cost.		Farms.	Cost.	
		Per acre.	Per ton.		Per acre.	Per ton.
Seeding by hand ^a	30	\$0.030	\$0.020	37	\$0.031	\$0.020
Mowing.....	52	.187	.124	37	.185	.118
Tedding.....	29	.123	.082	21	.156	.100
Raking.....	52	.087	.058	37	.103	.066
Loading, unloading, and putting into the barn.....	52	.743	.495	37	1.060	.680
Total.....	.....	1.170	.779	.....	1.535	.984

^a Cost during life of meadow.

HORSE LABOR.

Mowing.....	52	\$0.243	\$0.162	37	\$0.240	\$0.154
Tedding.....	29	.160	.107	21	.202	.130
Raking.....	52	.113	.075	37	.134	.085
Loading, hauling, and putting into barn.....	52	.295	.197	37	.435	.279
Total.....	.....	.811	.541	.....	1.011	.648
Cost of man and horse labor.....	.....	1.981	1.310	.....	2.546	1.632

MACHINERY CHARGES.

Haying machinery is used but a few days per year on these farms. When ordinary care is used in operating machinery, the cost of repairs is but a small portion of the total cost of production. Machinery charges include repairs, interest, and depreciation or replacement, but not the value of labor in making repairs, regarding which it was not possible to get accurate data. However, this item is not important.

Interest on machinery, in most cases, equals the cost of repairs. It has been figured at 5 per cent, which is the prevailing rate in each region. (See Table XIV.)

TABLE XIV.—*Repairs, interest, and depreciation on hay machinery.*

REPAIRS.

Kind of machine.	52 farms in Steuben County, N. Y.						37 farms in Washington County, Pa.					
	Farms reporting.	Cost.					Farms reporting.	Cost.				
		Per day used.	Per year.	Total for life.	Per acre.	Per ton.		Per day used.	Per year.	Total for life.	Per acre.	Per ton.
Seeders.....	30						.....					
Mowers.....	52	\$0.295	\$1.52	\$16.19	\$0.033	\$0.022	37	\$0.328	\$1.190	\$17.20	\$0.031	\$0.020
Tedders.....	29	.148	.60	10.24	.012	.008	21	.110	.488	11.84	.011	.007
Rakes.....	52	.226	.64	11.26	.013	.008	37	.118	.289	7.28	.007	.004

TABLE XIV.—*Repairs, interest, and depreciation on hay machinery—Continued.*

INTEREST.

Kind of machine.	52 farms in Steuben County, N. Y.						37 farms in Washington County, Pa.					
	Farms reporting.	Cost.					Farms reporting.	Cost.				
		Per day used.	Per year.	Total for life.	Per acre.	Per ton.		Per day used.	Per year.	Total for life.	Per acre.	Per ton.
Hand seeders.	17	\$0.058	\$0.052	\$1.02	\$0.004	\$0.003	11	\$0.091	\$0.051	\$1.05	\$0.006	\$0.004
Wheelbarrow seeders.	13	.340	.271	4.75	.019	.012	37	.315	1.141	16.51	.030	.019
Mowers.	52	.235	1.200	12.78	.027	.018	37	.315	1.141	16.51	.030	.019
Tedders.	29	.204	.819	14.07	.017	.011	21	.226	.784	19.03	.017	.011
Rakes.	52	.222	.629	11.08	.013	.008	37	.310	.757	19.07	.019	.012

REPAIRS, INTEREST, AND DEPRECIATION.

Hand seeders.	17	\$0.172	\$0.155	\$3.02	\$0.011	\$0.007	11	\$0.262	\$0.146	\$3.00	\$0.017	\$0.011
Wheelbarrow seeders.	13	1.078	.86	15.05	.061	.040	37	1.450	5.280	76.46	.138	.088
Mowers.	52	1.330	6.83	72.83	.148	.099	37	1.450	5.280	76.46	.138	.088
Tedders.	29	.805	3.25	55.45	.066	.044	21	.711	2.470	61.02	.056	.036
Rakes.	52	.927	2.62	46.20	.053	.035	37	.903	2.200	55.48	.057	.037

WORK DONE BY MACHINERY.

Table XV shows the amount of work done by machinery in acres and in tons per day, per year, and during its life. On the Pennsylvania farms, mowers, tedders, and rakes cover a greater acreage during life than they do on the New York farms.

TABLE XV.—*Service rendered by machinery.*

52 FARMS IN STEUBEN COUNTY, N. Y.

Kind of machine.	Farms reporting.	Width of machine.	Amount of hay handled.					
			Per day.		Per year.		Total during life.	
			Aeres.	Tons.	Aeres.	Tons.	Aeres.	Tons.
		<i>Fect.</i>						
Hand seeders.	17	-----	15.53	-----	13.99	-----	271.20	406.80
Wheelbarrow seeders.	13	-----	17.69	26.53	14.11	21.16	247.00	370.50
Mowers.	52	5.14	8.94	13.41	46.10	69.15	490.00	735.00
Tedders.	29	8.76	12.07	18.10	48.65	82.97	831.00	1,247.00
Rakes.	52	10.82	17.30	25.95	49.00	73.50	862.00	1,293.60

37 FARMS IN WASHINGTON COUNTY, PA.

Hand seeders.	11	-----	15.00	-----	8.37	-----	171.00	273.20
Wheelbarrow seeders.	37	5.92	10.51	16.40	38.13	59.50	551.00	859.50
Mowers.	21	6.85	12.66	19.75	44.10	68.80	1,070.00	1,670.00
Tedders.	37	10.65	15.65	24.42	38.14	59.50	961.00	1,498.00

LIFE OF MACHINERY.

Table XVI shows the service rendered by machinery in days used, per year and for its life. Mowers are used about the same number of days in each region. Tedders are used 16 more days and rakes

11 more days on the Pennsylvania farms than on the New York farms. All haying machinery is well taken care of in both sections. The practice of allowing machinery to stand out of doors, customary in some parts of the middle west, is not common in the east.

TABLE XVI.—*Life of machinery and number of days used.*

Kind of machine.	52 farms in Steuben County, N. Y.				37 farms in Washington County, Pa.			
	Farms report- ing.	Days used per year.	Years' service.	Days used during life.	Farms report- ing.	Days used per year.	Years' service.	Days used during life.
Hand seeders.....	17	0.904	19.40	17.52	11	0.557	20.25	11.45
Wheelbarrow seeders.....	13	.797	17.50	13.96	.....	.....	.....	.....
Mowers.....	52	5.150	10.65	54.80	37	3.620	14.46	52.42
Tedders.....	29	4.030	17.07	68.85	21	3.480	24.28	84.50
Rakes.....	52	2.830	17.60	49.80	37	2.430	25.20	61.40

In Table XVII are shown comparative figures on interest and taxes on hay land for the two regions:

TABLE XVII.—*Interest and taxes on hay land.*

Item.	52 farms in Steuben County, N. Y.		37 farms in Wash- ington County, Pa.	
	Per acre.	Per ton.	Per acre.	Per ton.
Average value of entire farm.....	\$55.35	.....	\$72.84	.....
Average value of hay land.....	\$0.10	.....	105.40	.....
Interest on hay land at 5 per cent.....	4.00	\$2.670	5.27	\$3.380
Taxes on hay land.....	.801	.534	1.054	.675
Interest and taxes.....	4.801	3.204	6.324	4.055

TOTAL COST OF PRODUCING HAY.

In Table XVIII is given a summary of the cost of all labor, of machinery charges, seed cost, taxes, and interest on hay land. This amounts to \$5 per ton for the New York farms and \$6.10 for the Pennsylvania farms. This cost is obtained by prorating the cost of seeding, tedding, etc., to cover the total hay area surveyed in each section.¹

Table XIX presents the cost of producing hay on farms where there is a charge for seeding and tedding. The cost of these operations, machinery charges, seed cost, taxes, and interest on land, amount to \$7.704 per acre and \$5.154 per ton for the New York and \$9.673 per acre and \$6.202 per ton for the Pennsylvania group.

On farms where hay is not seeded with a grain crop, but where the seed bed is prepared especially, there will be an additional labor charge of perhaps from 75 cents to \$1 per acre per year, depending upon the life of the meadow.

¹ Commercial fertilizers are used very little in the areas studied, and not at all on the hay crop. Hence there is no charge for fertilizers.

TABLE XVIII.—*Cost of man and horse labor, repairs, interest, and depreciation on machinery for haying operations.*

Operation.	52 farms in Steuben County, N. Y.				37 farms in Washington County, Pa.			
	Farms reporting each operation.	Cost.			Farms reporting each operation.	Cost.		
		Per day.	Per acre.	Per ton.		Per day.	Per acre.	Per ton.
Seeding with hand seeder.....	17	\$2.052	\$0.041	\$0.027	11	\$2.26	\$0.048	\$0.031
Seeding with wheelbarrow seeder.....	13	2.958	.091	.060				
Average for seeding.....	30	2.553	.065	.042	11	2.26	.048	.031
Mowing.....	52	5.170	.578	.385	37	5.920	.563	.360
Tedding.....	29	4.225	.319	.233	21	5.261	.414	.266
Raking.....	52	4.397	.253	.168	37	4.623	.294	.188
Loading, hauling, and putting into barn.....	52	8.290	1.038	.692	37	8.980	1.495	.959
Total for all operations.....		24.635	2.283	1.520		27.024	2.814	1.804

TABLE XIX.—*Actual cost of producing 4,047 tons of hay on 52 farms in Steuben County, N. Y., and 2,201 tons on 37 farms in Washington County, Pa.*

Item of cost.	Cost of man and horse labor, repairs, interest, and depreciation on machinery.			
	52 farms in Steuben County, N. Y.		37 farms in Washington County, Pa.	
	Per acre.	Per ton.	Per acre.	Per ton.
Preparing seed bed.....				
Seeding.....	\$0.031	\$0.021	\$0.035	\$0.022
Mowing.....	.578	.385	.563	.360
Tedding.....	.181	.121	.270	.173
Raking.....	.253	.168	.294	.188
Loading, hauling, and putting into barn.....	1.038	.692	1.495	.959
Repairs, interest, and depreciation on hay loaders.....	.012	.008		
Seed.....	2.093	1.395	2.657	1.702
Taxes and 5 per cent of hay land.....	.620	.430	.533	.343
	4.801	3.204	6.324	4.055
Total.....	7.514	5.002	9.516	6.100

COST OF BALING HAY.

Only a small per cent of the hay producers in the areas surveyed own their own hay presses. Most of the market hay is baled by the country buyer and shipper, or else by custom balers. The customary price for baling is \$1.50 per ton, and often the hay grower is expected to furnish one or two pitchers and board the press crew of three or four men. With the ordinary crew this brings the cost of pressing up to about \$2 per ton.¹

COST OF HAULING TO MARKET.

It is almost impossible to determine the average cost of hauling hay to market without making special time studies, since hay is marketed in quantities varying from a ton to a carload. This operation is usually performed by farm man labor and horse labor, and not by those making a business of hauling, as is the case in the Middle West, where hay is grown on a more extensive scale. The

¹ Considerable information secured in this study on the management of baling crews and the cost of baling will be published in other bulletins.

condition of the roads has a decided influence on the cost, as bad roads make it impossible to haul a full load and necessitate a longer time per trip.

From the report of 25 farmers in the New York area it was found that the average distance to market was 3 miles and the cost of hauling 70 cents per ton.

TABLE XX.—*Labor cost per ton when the yield varies. (52 farms in Steuben County, N. Y.)*

Operation.	Labor cost per ton when yield is—		
	3 tons per acre.	1.50 tons per acre.	1 ton per acre.
Seeding.....	\$0.021	\$0.042	\$0.063
Mowing.....	.192	.385	.577
Tedding.....	.116	.233	.349
Raking.....	.084	.168	.252
Loading, hauling, and unloading.....	.692	.692	.692
Total.....	1.105	1.520	1.933



FIG. 3.—A good stand of timothy and clover, yielding over two tons per acre. The cost of production decreases and profits increase as the yield per acre increases.

EFFECT OF YIELD ON THE COST OF LABOR PER TON.

The cost of labor per ton is directly affected by yield in seeding, mowing, tedding, and raking, since the amount of work accomplished per hour in these operations is nearly the same for a light yield as for a heavy one. Even the cost of loading by hand, hauling, and putting into the barn is but slightly affected by variation in yield.

For the purpose of illustrating the effect of yield upon labor cost per ton Table XX has been prepared, based on the cost in the New York area, where the yield is 1.50 tons per acre. It will be seen that the labor cost per ton decreases as the yield increases, the cost with a 1-ton yield being almost double the cost with a 3-ton yield. (See fig. 3.)

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THE FOUR ESSENTIAL FACTORS IN
THE PRODUCTION OF MILK OF LOW
BACTERIAL CONTENT

By

S. HENRY AYERS, LEE B. COOK, and PAUL W. CLEMMER.
of the Dairy Division

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FACTORS INFLUENCING THE SANITARY QUALITY OF MILK.

The production of milk of a high sanitary quality involves a knowledge of the influence of numerous factors. Whether these factors are all grouped under one head and considered as a single unit or are grouped into several units, each directly connected with a separate phase of the production of sanitary milk, may not at first thought be of any importance.

Consideration of that point, however, must lead to the view that to deal intelligently with the factors which influence the sanitary quality of milk they must be grouped in such way as to bring together those which are of importance in connection with a definite phase of production. As an example, the question of abundant light

¹The authors acknowledge their indebtedness to T. E. Woodward, of the Dairy Division; also to W. R. Hale and W. F. Turner, formerly of this division, who made the work possible through their supervision of the experimental barn. They also extend their thanks to the dairy farmers near Grove City, Pa., and to R. R. Welch, of this division, who assisted in making a practical demonstration of the work.

may be mentioned. It has long been recognized that an abundance of light is necessary for the production of high-grade milk, but that factor must first be placed under a certain group of factors before it can be adjudged correctly. Depending upon whether it bears a direct relation to the bacterial content of milk or exerts a marked influence on the health and comfort of the cattle, it should be grouped accordingly.

In view of these facts, the following group of factors have been selected as a means of clarifying the subject:

1. Factors concerned in the production of milk which is practically free from visible dirt and which has a low bacterial content.
2. Factors most directly concerned in the prevention of the infection of milk with pathogenic organisms.
3. Factors of importance in connection with the health of the cattle.
4. Factors concerned in providing and maintaining conditions suitable for the production of a food product, even though they may not directly affect the quality of the product.

It is realized that some factors may enter into more than one of the groups above, but their greatest importance can generally be assigned to one definite group. For example, the sterilization of utensils is of primary importance in the production of milk of low bacterial content, but it is also a measure in the prevention of infection with pathogenic organisms.

This paper considers only the factors in group 1; that is, those concerned in the production of milk practically free from visible dirt and of low bacterial content.

It is not to be questioned that milk of low bacterial content may be produced under conditions in which every possible factor is controlled, but it is reasonable to suppose that, relatively speaking, some factors may be of more importance than others. It may be possible, therefore, on the average farm, to produce milk of low bacterial content by the combination of a certain few factors which affect the quality of milk more than others. Some of the factors have been extensively investigated, and the results of much excellent work pertaining to the subject have been published. Such work, however, has dealt largely with the value of one factor or with the comparative importance of two or more factors. In our work the problem has been studied from a somewhat different angle.

The endeavor has been to determine methods for the production of milk of low bacterial content in the barn of the ordinary type. The experimental work was confined to a study of conditions which affect the bacterial content of milk sufficiently to be measured. While it is realized that many conditions under which milk is produced may affect its quality from a sanitary or economic standpoint, no attempt was made to study them unless they could be measured in terms of the bacterial count.

OBJECTS OF THE INVESTIGATION.

The objects of the investigation may be outlined as follows:

1. To work on only fresh milk at the time of milking, in order to eliminate the factor of bacterial growth.
2. To obtain conditions as bad as possible in an experimental barn in order to improve them and also to determine the number of bacteria in fresh, dirty milk.
3. To introduce one factor of improvement at a time, so as eventually to obtain milk of low bacterial content.
4. To return to the dirty conditions and then again produce low-count milk by the application of the necessary factors with the object of checking the value of the factors previously determined.
5. To show the relative importance of the selected factors.
6. To use a combination of the essential factors in a practical manner on farms in order to determine their value when used by the average farmer.
7. To show the growth of bacteria in various grades of milk (graded from a bacterial standpoint) when held for different periods of time at various temperatures.

Since the term "production of milk" is usually considered to cover the entire period in which it is in the farmer's hands, the bacterial content during production, as used in that sense, must be considered from two distinct standpoints, first, the bacteria introduced through contamination, and second, their growth in the milk.

In this paper, however, we shall consider the term "production of milk" to cover only the period from the time the milk leaves the cow until it is in the delivery cans or bottles, which includes the time the milk is subject to the usual sources of contamination. The time the milk is held on the farm will be considered as an entirely different phase of production, since the bacterial content during that period is not usually influenced by contamination, but is subject to increase through bacterial growth.

Particular attention is called to the fact that extreme conditions of filth were used merely to emphasize the importance of certain factors. No legitimate excuse can be conceived for the production of milk from dirty cattle or in a filthy stable.

DESCRIPTION OF BARN AND METHODS USED IN THE PRODUCTION OF THE MILK.

For the experiments a small barn was constructed at the Dairy Division farm at Beltsville, Md., a view of which is shown as figure 1. The building provided space for four cows and was of wooden construction throughout, including floor, gutter, and mangers. The walls were left in the rough; that is, with exposed beams, etc. The loft above the cows was constructed of narrow boards laid from 1 to 2 inches apart on crossbeams. From the loft hay was thrown down and the cows fed just before milking. The stable had two doors and two windows; the latter were small and provided only 2

square feet of light for each cow. Five hundred cubic feet of air space was provided for each cow. An untrained milker, wearing ordinary work clothes and giving no special attention to the cleanliness of his hands, was employed to milk and take care of the cows.

During the work the cows were alternated from time to time in order to equalize any unusual results due to the individual animal. For example, in working with the small-top and open pails two cows were milked first into the open pail and a few days later were milked into the small-top pail.

In all the work the milk was poured unstrained into cans in the barn. The small-top pail used in the experiments was the type with

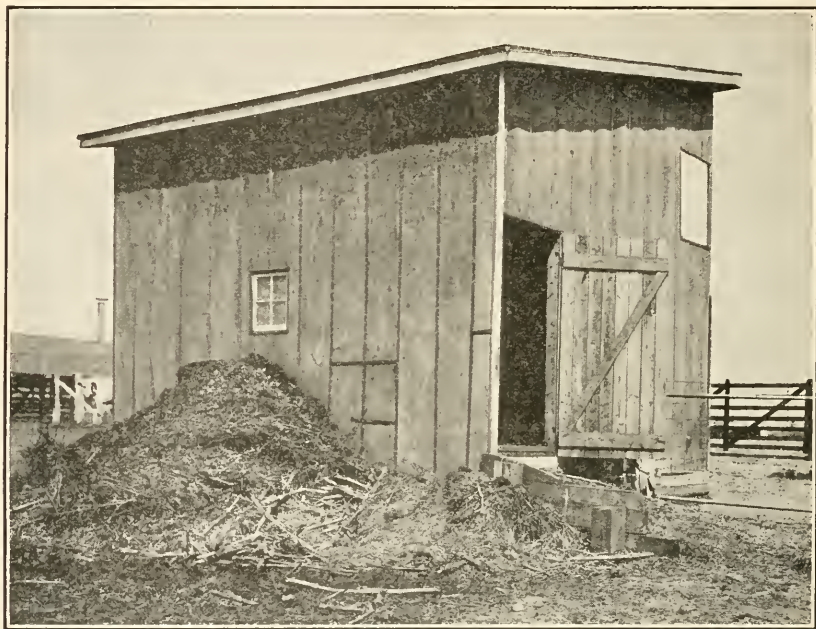


FIG. 1.—Experimental barn used in this investigation.

a hood or cover on an ordinary pail, as shown in figure 2. Utensils were sterilized by being placed in a sterilizer, steamed for 30 minutes, and afterwards allowed to remain there until used. When the utensils were not sterilized they were merely washed clean and inverted in the milk house. Covers were not placed on the cans, and the utensils were left in that position until time to milk.

Sterile utensils in the strict sense of the term means their absolute freedom from living organisms. When the statement is made that utensils were sterilized it means that they were free from all bacteria which are destroyed by flowing steam at 100° C. (212° F.). There are, of course, a few spores which are resistant to flowing steam and which can be destroyed only by steam of high temperature under pressure.

METHOD OF SAMPLING AND MAKING THE BACTERIAL COUNT.

After milking, the cans of milk were promptly carried from the barn to the milk room, a distance of a few hundred feet, situated in the same building as the laboratory. Long-handled white-agate dippers, cleaned between milkings and sterilized just before using, were used to stir the milk and to take the sample. A separate dipper was used for each sample, and the milk was poured carefully into sterile pint bottles, which were immediately closed with sterile caps.

The fact that the laboratory was in the same building made it possible to pour the plates within one hour after milking. The same routine was followed at both morning and evening milkings, regardless of how the other factors varied. Since the interpretation of results depends partly on the nature of the medium and on its subsequent incubation it is necessary to state



FIG. 2.—The small-top pail used in the experiments.

exactly how the counts were obtained. For the sake of uniformity plain-extract agar, prepared according to the revised recommendations of the Committee on Standard Methods of Bacterial Milk Analysis,¹ was used. The plates were incubated for five days at 30° C. (86° F.) and counted with the aid of a hand glass of three and one-half diameters magnification.

THE EXPERIMENTAL WORK.

In the experiments the plan was to begin with conditions in which the barn and cows were as filthy as possible. When those conditions

¹ Rochester meeting of American Public Health Association, September, 1915 (Committee on Standard Methods).

were obtained it was the intention, by the gradual elimination of certain factors which contribute to the contamination of milk, to produce milk that was practically free from visible dirt and had a low bacterial content. Following that, the next step was to duplicate the conditions in order to determine again the value of the essential factors. To show clearly the scope of the work and the conditions under which the milk was produced, the experiments are listed in the order in which they were conducted:

Experiment No.	Period covered.	Conditions.
1.	July 22, to August 14, 1915-----	Cows and floor were dirty and the manure was removed weekly. The utensils were not sterilized.
2.	September 14 to October 7, 1915-----	Cows and floor were dirty and the manure was removed weekly. The utensils were sterilized.
3.	November 10 to 24, 1915-----	Cows and floor were dirty and the manure was removed twice a week. Udders and teats of the cows were washed and the utensils were sterilized.
4.	February 27 to April 10, 1916-----	Cows were clean and bedded, floor was clean, and the manure was removed daily. Udders and teats of the cows were washed; also of two others not washed. The utensils were sterilized.
5.	April 11 to May 6, 1916-----	Cows and floor were dirty and the manure was removed weekly. The utensils were sterilized.
6.	May 8 to 31, 1916-----	Cows and floor were dirty and the manure was removed weekly. The utensils were not sterilized.
7.	June 5 to 13, 1916-----	Cows and floor were clean and the manure was removed daily. Udders and teats of the cows were washed and the utensils were sterilized.

During the dates not covered by the periods above the cows were kept in the barn and the relative value of the factors was studied by other methods. The general conditions of the barn as previously described, method of feeding, etc., were not changed during the experiments. The results obtained in the various experiments above outlined will be described in their proper order.

EXPERIMENT NO. 1 (COWS AND FLOOR DIRTY, MANURE REMOVED WEEKLY, UTENSILS NOT STERILIZED).

The first condition of the barn was one of extreme filth. Four cows were placed there on January 28, 1915, and the first experiment was begun on July 22 of that year. In the intervening period no atten-

tion was given to the stable except to remove manure. Dust was allowed to accumulate in the barn; consequently at the beginning of the first experiment its condition was little if any better than that of the average low-grade barn. During the experiment, which extended from July 22 to August 14, the manure was removed once a week; as a result varying quantities of filth were present on the floor and on the cows. A picture of the barn just before the weekly removal of the manure is shown in figure 3. It will be noted that the gutter was filled with manure and the floor almost entirely covered. Figure 4 shows one of the cows at that time. It will be seen that

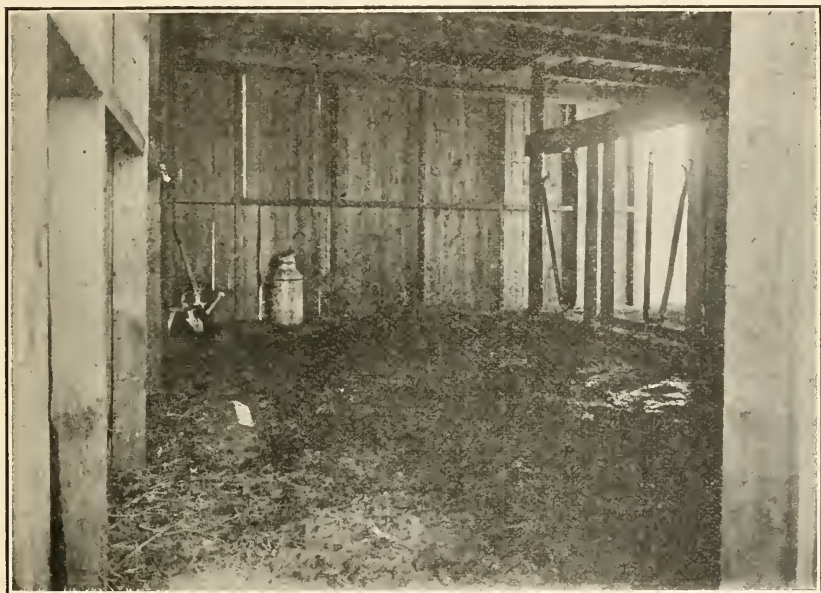


FIG. 3.—Condition of barn during Experiment No. 1.

the flanks, udder, and teats of the cow were almost entirely covered with manure. The general type of milker employed throughout the experiments may also be seen in the picture. Under such barn conditions and with unsterilized utensils it seemed probable that the bacterial counts obtained would be as high as those from any other dirty barn. It is not intended to intimate that conditions in the average barn in this country are as bad as these, but, as stated, for the purposes of the experiment it was desired to have the worst possible conditions.

Two cows were milked into open and the other two into small-top pails, which were washed clean but not sterilized. The milk was then poured into clean, unsterilized cans in the barn, after which it was carried to the milk house, where samples were taken immediately both night and morning.

At each milking a sample was taken from the open pail and one from the small-top pail. In this connection it must be understood that the sample came from a can, but that the open or small-top pail was used in the milking.

Table 1 shows the bacterial analyses of 32 samples of milk. The numbers represent milkings, both in the table and throughout the bulletin. It will be seen from the table that the first count of milk from the open pail was 14,000 bacteria per cubic centimeter. As the manure accumulated on the floor during the first week and the cows became more dirty the bacterial content of the milk increased. The



FIG. 4.—Condition of one of the cows during Experiment No. 1.

highest count obtained with the open pail was 1,200,000 and with the small-top pail 750,000 bacteria per cubic centimeter. Throughout the experiment the counts from the open pail were higher than the corresponding counts from the small-top pail. The difference is represented fairly well by the average count of the 32 samples from the open pail, which was 497,653 bacteria per cubic centimeter, as compared with 368,214 for the small-top pail.

It must be remembered, however, that the actual value of the small-top pail can not be determined accurately from these results for the reason that the utensils were not sterilized, which brings in an unknown factor, since the number of bacteria introduced into the milk from the unsterilized utensils is variable. The figures show that the use of the small-top pail was of some value, even when none of the utensils were sterilized.

TABLE 1.—*Bacteria per cubic centimeter in dual samples of fresh milk produced under conditions described in Experiment No. 1.*

Date.	Sample No.	Open pail.	Small-top pail.	Date.	Sample No.	Open pail.	Small-top pail.
1915.				1915.			
July 22, p. m.	1	14,000	-----	Aug. 5, a. m.	18	600,000	600,000
July 23, a. m.	2	170,000	45,000	Aug. 5, p. m.	19	650,000	550,000
July 23, p. m.	3	125,000	60,000	Aug. 6, p. m.	20	400,000	-----
July 24, a. m.	4	280,000	150,000	Aug. 7, a. m.	21	300,000	250,000
July 26, p. m.	5	600,000	450,000	Aug. 9, a. m.	22	-----	400,000
July 27, a. m.	6	-----	200,000	Aug. 9, p. m.	23	550,000	500,000
July 27, p. m.	7	240,000	130,000	Aug. 10, a. m.	24	-----	500,000
July 28, a. m.	8	350,000	160,000	Aug. 10, p. m.	25	350,000	450,000
July 28, p. m.	9	390,000	175,000	Aug. 11, a. m.	26	400,000	300,000
July 29, a. m.	10	320,000	200,000	Aug. 11, p. m.	27	900,000	450,000
July 29, p. m.	11	500,000	340,000	Aug. 12, a. m.	28	1,200,000	500,000
July 30, a. m.	12	900,000	750,000	Aug. 12, p. m.	29	800,000	400,000
July 31, a. m.	13	-----	350,000	Aug. 13, a. m.	30	600,000	450,000
Aug. 3, a. m.	14	-----	750,000	Aug. 13, p. m.	31	450,000	300,000
Aug. 3, p. m.	15	550,000	-----	Aug. 14, a. m.	32	700,000	500,000
Aug. 4, a. m.	16	-----	400,000	Average.....		497,653	368,214
Aug. 4, p. m.	17	600,000	-----				

Perhaps the most interesting point brought out by the results was the relatively low bacterial count obtained in all samples. It is reasonable to suppose that milk produced under such extremely filthy conditions would contain millions of bacteria per cubic centimeter. The figures indicate very clearly, however, that large numbers of bacteria are not commonly found in fresh milk. Even when extremely high counts are obtained, they are probably attributable to some other factor, such as growth or subsequent infection during the various stages of handling. Throughout the experiments the milk was examined before cooling, as it was the intention to avoid the variable factor of contamination from unsterilized coolers.

EXPERIMENT NO. 2 (COWS AND FLOOR DIRTY, MANURE REMOVED WEEKLY, UTENSILS STERILIZED).

Having determined the number of bacteria in fresh milk produced under extreme conditions of filth, where unsterilized utensils were used, the next step was to use one factor which was considered of utmost importance in preventing contamination, namely, sterilized utensils. Samples of milk were taken from September 14 to October 7, 1915, under conditions as nearly identical as possible with those of the previous experiment, with the exception that the cans and pails were sterilized.

By the use of sterilized utensils a remarkable decrease in the bacterial content of the milk was found. From the results of 36 samples shown in Table 2 it will be seen that the average count of milk from open pails was 22,677 bacteria per cubic centimeter, compared with 17,027 from small-top pails. Comparison with the results shown in Table 1 is convincing proof of the value of sterilized utensils. It should be remembered that the figures represent samples taken under filthy conditions and that the only factor contributing to the difference in the bacterial count was the use of sterilized utensils.

The range in the bacterial content of samples taken from the open pail during the experiment was from 2,500 to 80,000, and in the sam-

ples from the small-top pail from 2,100 to 60,000 per cubic centimeter. It is quite remarkable that the counts were not higher on account of the dirty condition of cows and barn floor.

TABLE 2.—*Bacteria per cubic centimeter in dual samples of fresh milk produced under conditions described in Experiment No. 2.*

Date.	Sample No.	Open pail.	Small-top pail.	Date.	Sample No.	Open pail.	Small-top pail.
1915.				1915.			
Sept. 14, a. m.	1	20,000	9,000	Sept. 25, p. m.	20	5,000	2,500
Sept. 15, a. m.	2	40,000	20,000	Sept. 27, a. m.	21	55,000	30,000
Sept. 15, p. m.	3	25,000	11,000	Sept. 27, p. m.	22	12,000	9,000
Sept. 16, a. m.	4	13,000	16,000	Sept. 28, a. m.	23	36,000	21,000
Sept. 16, p. m.	5	10,000	3,500	Sept. 28, p. m.	24	4,100	3,400
Sept. 17, a. m.	6	12,000	23,000	Sept. 29, a. m.	25	25,000	60,000
Sept. 17, p. m.	7	5,600	2,400	Sept. 30, a. m.	26	14,000	12,000
Sept. 18, a. m.	8	10,500	45,000	Sept. 30, p. m.	27	9,000	12,000
Sept. 20, a. m.	9	75,000	35,000	Oct. 1, a. m.	28	11,000	9,000
Sept. 20, p. m.	10	4,500	3,200	Oct. 1, p. m.	29	65,000	20,000
Sept. 21, a. m.	11	32,000	24,000	Oct. 2, a. m.	30	80,000	60,000
Sept. 21, p. m.	12	5,600	2,500	Oct. 4, a. m.	31	40,000	55,000
Sept. 22, a. m.	13	7,500	3,800	Oct. 5, a. m.	32	18,000	9,000
Sept. 22, p. m.	14	14,500	2,600	Oct. 5, p. m.	33	15,000	5,500
Sept. 23, a. m.	15	16,000	12,500	Oct. 6, a. m.	34	60,000	45,000
Sept. 23, p. m.	16	2,500	2,800	Oct. 6, p. m.	35	25,000	13,000
Sept. 24, a. m.	17	18,000	14,000	Oct. 7, a. m.	36	8,500	7,000
Sept. 24, p. m.	18	5,600	2,100	Average.....		22,677	17,027
Sept. 25, a. m.	19	16,000	7,200				

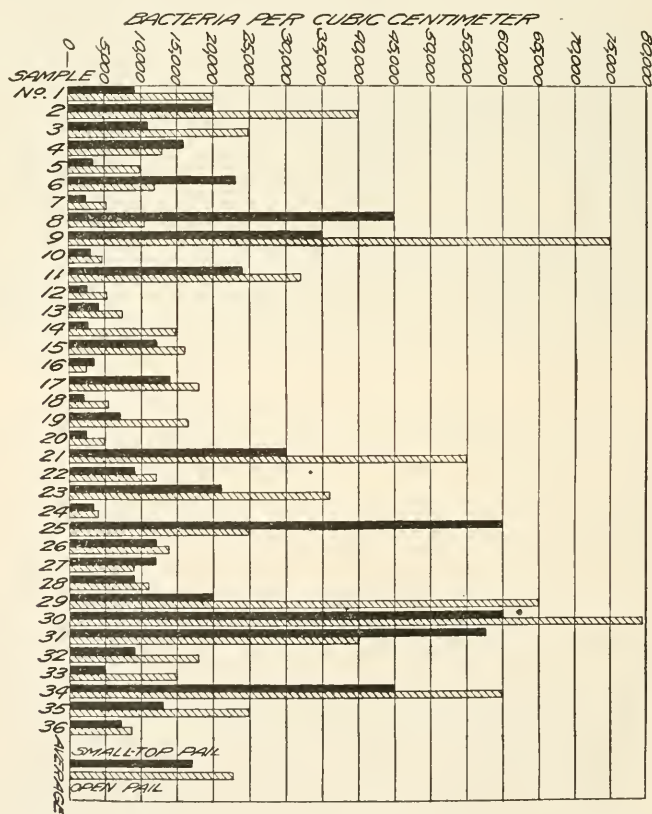


FIG. 5.—Bacterial content of milk from sterilized open and small-top pails during Experiment No. 2.

From the results it is possible to determine something of the value of the small-top as compared with that of the open pail. The average of the bacterial counts of milk from the small-top pail as given in Table 2 was about 5,500 bacteria per cubic centimeter lower than that of milk from the corresponding open pail. The true value of the small-top pail, however, is more definitely shown in figure 5, in which the bacterial count of each sample of milk is shown and plotted in columns. The comparative heights indicate the difference in the number of bacteria per cubic centimeter in milk from open and small-top pails at the same milking. In 29 of the 36 samples the bacterial count of milk from the open pail was higher than that from the small-top. The results confirm the conclusions of previous investigators as to the value of the small-top pail.

EXPERIMENT NO. 3. (COWS AND FLOOR DIRTY, MANURE REMOVED TWICE A WEEK, UDDERS AND TEATS OF THE COWS WASHED, UTENSILS STERILIZED).

In Experiment No. 2 the use of sterilized utensils, as has been shown, resulted in a remarkable lowering of the bacterial count. In Experiment No. 3, where sterilized utensils were used, a second factor was introduced, which consisted in washing the udders and teats of the cows.

The condition of the barn, as shown in figure 6, was the same as in the previous experiments except that the manure was removed twice

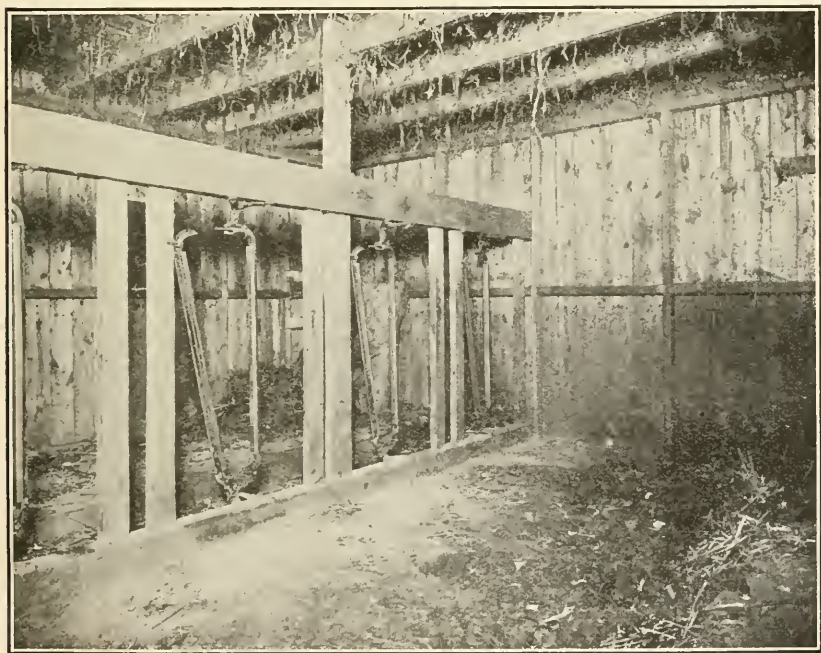


FIG. 6.—Condition of barn during Experiment No. 3.

a week. It will be noticed that the walls and ceiling were extremely dirty. Hay protruded through the open ceiling, and the gutter was completely filled with manure which was scattered over the floor toward the stanchions.

The condition of the cows is well illustrated by figure 7. Their flanks were caked with manure, but the visible dirt was removed from the udders, which were washed before each milking. After having been thoroughly washed with clean water and a cloth they were wiped with another clean, damp cloth rinsed in clean water. The flanks of the cows, which were liable to be rubbed by the milker's arm, also were kept clean.

During the period from November 10 to 24, 1915, 18 samples of milk were examined from the open and 23 samples from the small-top pail. The results in Table 3 show that the average number of bacteria in milk from the open pail was 6,166 bacteria per cubic centimeter, compared with 2,886 from the small-top pail.

In the experiment 12 samples of milk were drawn directly from the udder into sterile tubes at about the middle of the milking. The average count of the milk from the four cows was 987 bacteria per cubic centimeter. The difference between that average and the average in the milk from the open pail is 5,179, which represents the number of bacteria per cubic centimeter introduced through external contamination. The average number of bacteria per cubic centimeter of 23 samples from the small-top pail was 2,886; subtracting 987 from the count, the remainder, 1,889 bacteria per cubic centimeter, represents the number added through external contamination.

TABLE 3.—*Bacteria per cubic centimeter in dual samples of fresh milk produced under conditions described in Experiment No. 3.*

Date.	Sample No.	Open pail.	Small-top pail.	Date.	Sample No.	Open pail.	Small-top pail.
1915.				1915.			
Nov. 10, p. m.	1	3,500	2,400	Nov. 19, p. m.	16	.....	4,500
Nov. 11, a. m.	2	38,000	3,100	Nov. 20, a. m.	17	3,600	4,300
Nov. 11, p. m.	3	1,700	2,400	Nov. 20, p. m.	18	.....	1,900
Nov. 12, a. m.	4	2,100	4,300	Nov. 22, a. m.	19	5,600	2,600
Nov. 12, p. m.	5	11,200	1,500	Nov. 22, p. m.	20	.....	5,000
Nov. 13, a. m.	6	4,300	1,800	Nov. 23, a. m.	21	8,500	4,100
Nov. 13, p. m.	7	2,800	1,000	Nov. 23, p. m.	22	.....	2,700
Nov. 15, p. m.	8	5,100	2,900	Nov. 24, a. m.	23	2,800	4,000
Nov. 16, a. m.	9	2,600	2,700				
Nov. 16, p. m.	10	.....	1,200				
Nov. 17, a. m.	11	3,200	2,700	Average of milk samples	.....	6,166	2,886
Nov. 17, p. m.	12	1,700	2,800	Average of 12 udder samples	.....	987	987
Nov. 18, a. m.	13	4,600	2,100				
Nov. 18, p. m.	14	3,500	2,000	Difference.....	.....	5,179	1,889
Nov. 19, a. m.	15	6,200	3,800				

The results show that when the udders were washed clean and the small-top, sterilized pail is used it is possible to produce milk of a bacterial count closely corresponding to the number found in milk

drawn directly from the udder. In all cases in which the bacteria in milk as it left the udder were counted the figures were low, because the results represented milk drawn in the middle of milking. It is, of course, well known that the "foremilk" contains more bacteria per cubic centimeter than the "middle milk." The difference between the bacterial count of the "regular milk" and of milk drawn directly from the udder ("middle milk") is designated as external contamination. As the foremilk is included in the regular milk this difference is probably greater than it should be.

The figures show also the value of the small-top pail. The difference, however, is not fairly represented by the average, for the reason that two samples of milk from the open pail were much higher than the others, which raised the average.

The most striking fact brought out by the experiment is that milk of a low bacterial count can be obtained, even under filthy conditions, if careful attention is given to three simple factors, namely, sterilized utensils, small-top pails, and clean udders and teats.

Attention is called to the fact that the experiment was conducted under filthy conditions in order to emphasize the value of the three factors mentioned. Common decency alone should not permit the production of milk under such conditions.



FIG. 7.—Condition of one of the cows during Experiment No. 3.

EXPERIMENT NO. 4 (COWS CLEANED AND BEDDED, FLOOR CLEAN, MANURE REMOVED DAILY, UDDERS AND TEATS OF TWO COWS WASHED AND OF TWO OTHERS NOT WASHED, UTENSILS STERILIZED).

The results obtained in previous experiments show that it was possible to obtain milk of a low bacterial count from dirty cows in a dirty stable. Under such conditions it is absolutely necessary to keep the udders and teats of the cows clean, but when the barn floor is covered with manure it is very difficult to do so. To attempt to produce low-count milk under conditions previously described would certainly show poor judgment on the part of the dairyman. It would be unreasonable, therefore, to attempt to keep the udder and teats of the cow absolutely clean when the animal is lying in manure a part of the day. The reasonable way to lessen the work of keeping the cows clean is to remove the manure at least once a day and to keep the floor clean. To keep the cows clean is a matter of economy as well as of common decency.

As may be noted in figure 8, the conditions of the walls and ceiling of the barn were the same as in previous experiments. Straw was used for bedding and the floors and gutter were practically free from manure. A picture of one of the cows also is shown in figure 9. The cows during this experiment were cleaned daily with currycomb and brush, and very little effort was required to keep them free from visible dirt.

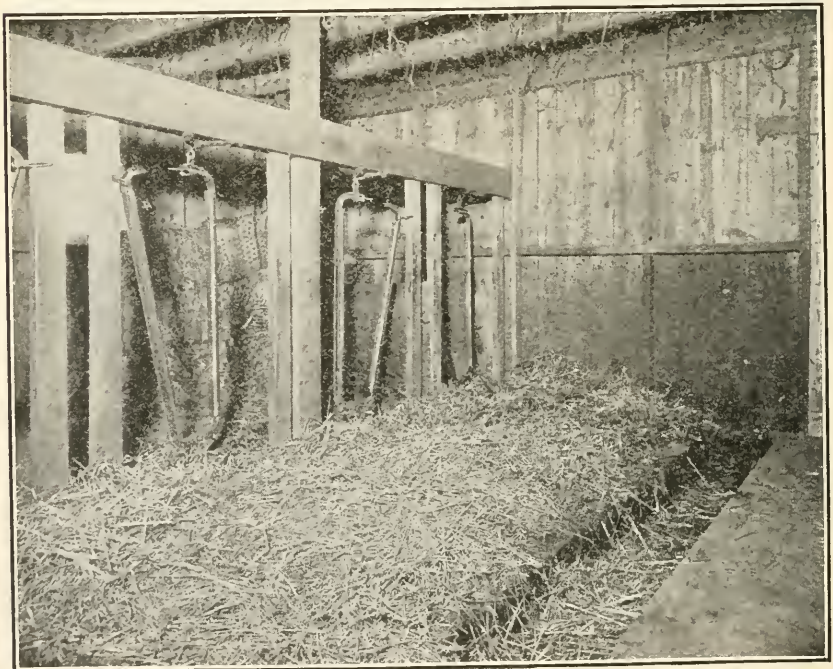


FIG. 8.—Condition of barn during Experiment No. 4.

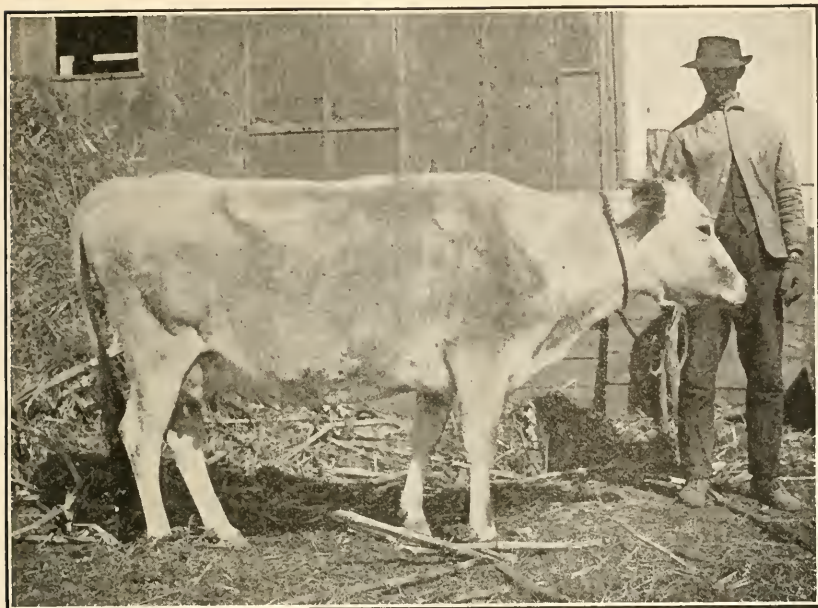


FIG. 9.—Condition of one of the cows during Experiment No. 4.

During the experiment, which was continued from February 28 to April 10, 1916, the udders and teats of two cows were washed just before milking and the other two were not washed. When the udders were washed clean water and a cloth were used, and they were then wiped with another clean cloth rinsed in clean water. Small-top pails were used throughout the experiment, and the utensils were sterilized.

The results of the bacteriological examination of the milk produced under these conditions are given in Table 4. The average bacterial count of milk when the udders and teats were washed was 2,154 per cubic centimeter, and 4,524 when they were not washed. The average counts show relatively little difference from a bacteriological standpoint so far as the quality of the milk is concerned. An examination of the table, however, shows that there is more uniformity of counts when the udder was washed than when unwashed. The samples from the washed udders ranged from 620 to 5,400, while those from the unwashed udders ranged from 1,090 to 20,000 bacteria per cubic centimeter. The results indicate that under the conditions it is possible to produce milk with a very low bacterial count without washing the udders. If it is desired, however, to produce milk of a uniformly low count when fresh, it is advisable to wash the udders.

TABLE 4.—*Bacteria per cubic centimeter in dual samples of fresh milk produced under conditions as described in Experiment No. 4.*

Date.	Sample No.	Udder and teats.		Date.	Sample No.	Udder and teats.	
		Washed.	Not washed.			Washed.	Not washed.
1916.				1916.			
Feb. 28, p. m.	1	1,600	1,800	Mar. 23, p. m.	37	810	2,660
Feb. 29, a. m.	2	3,700	9,900	Mar. 24, a. m.	38	1,350	4,800
Feb. 29, p. m.	3	5,400	3,600	Mar. 24, p. m.	39	1,300	2,970
Mar. 1, a. m.	4	2,200	6,500	Mar. 25, a. m.	40	2,410	4,010
Mar. 1, p. m.	5	4,000	6,300	Mar. 26, p. m.	41	1,350	4,200
Mar. 2, a. m.	6	3,300	4,700	Mar. 27, a. m.	42	2,740	4,750
Mar. 2, p. m.	7	1,130	2,250	Mar. 27, p. m.	43	1,530	6,700
Mar. 3, a. m.	8	2,270	5,300	Mar. 28, p. m.	44	2,900	3,600
Mar. 3, p. m.	9	1,900	3,100	Mar. 29, a. m.	45	2,300	3,200
Mar. 4, a. m.	10	2,700	6,000	Mar. 29, p. m.	46	2,000	5,100
Mar. 5, p. m.	11	983	1,520	Mar. 30, a. m.	47	3,900	3,500
Mar. 9, a. m.	12	3,900	13,300	Mar. 30, p. m.	48	1,800	3,300
Mar. 9, p. m.	13	2,500	5,100	Mar. 31, a. m.	49	4,200	6,900
Mar. 10, a. m.	14	1,400	20,400	Mar. 31, p. m.	50	1,500	4,100
Mar. 10, p. m.	15	1,370	1,200	Apr. 1, a. m.	51	4,700	3,400
Mar. 11, a. m.	16	1,150	2,370	Apr. 3, a. m.	52	1,600	7,400
Mar. 12, p. m.	17	830	1,050	Apr. 3, p. m.	53	2,300	4,100
Mar. 13, a. m.	18	1,480	2,210	Apr. 4, a. m.	54	3,400	4,700
Mar. 13, p. m.	19	620	1,120	Apr. 4, p. m.	55	1,400	5,500
Mar. 14, a. m.	20	3,600	8,700	Apr. 5, a. m.	56	2,200	5,300
Mar. 14, p. m.	21	910	1,550	Apr. 5, p. m.	57	1,900	2,200
Mar. 15, a. m.	22	1,920	2,350	Apr. 6, a. m.	58	2,900	7,300
Mar. 15, p. m.	23	820	2,070	Apr. 6, p. m.	59	800	5,200
Mar. 16, a. m.	24	2,550	14,800	Apr. 7, a. m.	60	1,400	3,300
Mar. 16, p. m.	25	1,140	1,090	Apr. 7, p. m.	61	2,700	1,500
Mar. 17, a. m.	26	2,190	2,110	Apr. 8, a. m.	62	3,400	9,400
Mar. 17, p. m.	27	1,970	2,680	Apr. 9, p. m.	63	3,200	2,300
Mar. 18, a. m.	28	1,300	2,040	Apr. 10, a. m.	64	2,100	3,900
Mar. 19, p. m.	29	1,520	1,510	Apr. 10, p. m.	65	2,400	7,200
Mar. 20, a. m.	30	820	3,070				
Mar. 20, p. m.	31	680	2,390	Average of milk samples.....		2,154	4,524
Mar. 21, a. m.	32	2,190	3,410	Average of udder samples.....		739	757
Mar. 21, p. m.	33	1,660	3,240				
Mar. 22, a. m.	34	2,070	6,020				
Mar. 22, p. m.	35	1,140	2,480				
Mar. 23, a. m.	36	2,290	3,110	Differences.....		1,415	3,767

The interpretation of the average counts obtained from washed and unwashed udders must receive special attention. The counts as they stand show 2,154 bacteria per cubic centimeter from cows with washed udders and 4,524 bacteria from those with unwashed udders. It can be said that washing the udder reduced the bacterial counts about 50 per cent, which agrees in a general way with the results obtained by Stocking.¹ This assertion should not be made, however, without taking into consideration the actual bacterial content of the milk. When the number of bacteria is small a 50 per cent reduction indicates practically no difference in the quality of the milk, as, for example, a count of 2,000 per cubic centimeter compared with 1,000. If, however, the counts were as high as 1,000,000 and 500,000, respectively, in the two samples, the factor causing the difference would still produce a 50 per cent reduction, but there would be a much greater difference in the quality of the milk with the higher counts.

The bacterial counts of the 65 samples in this experiment have been plotted and are shown in figure 10, which brings out in a striking manner the fact that milk from the washed udders has

¹ See list of references at end of bulletin.

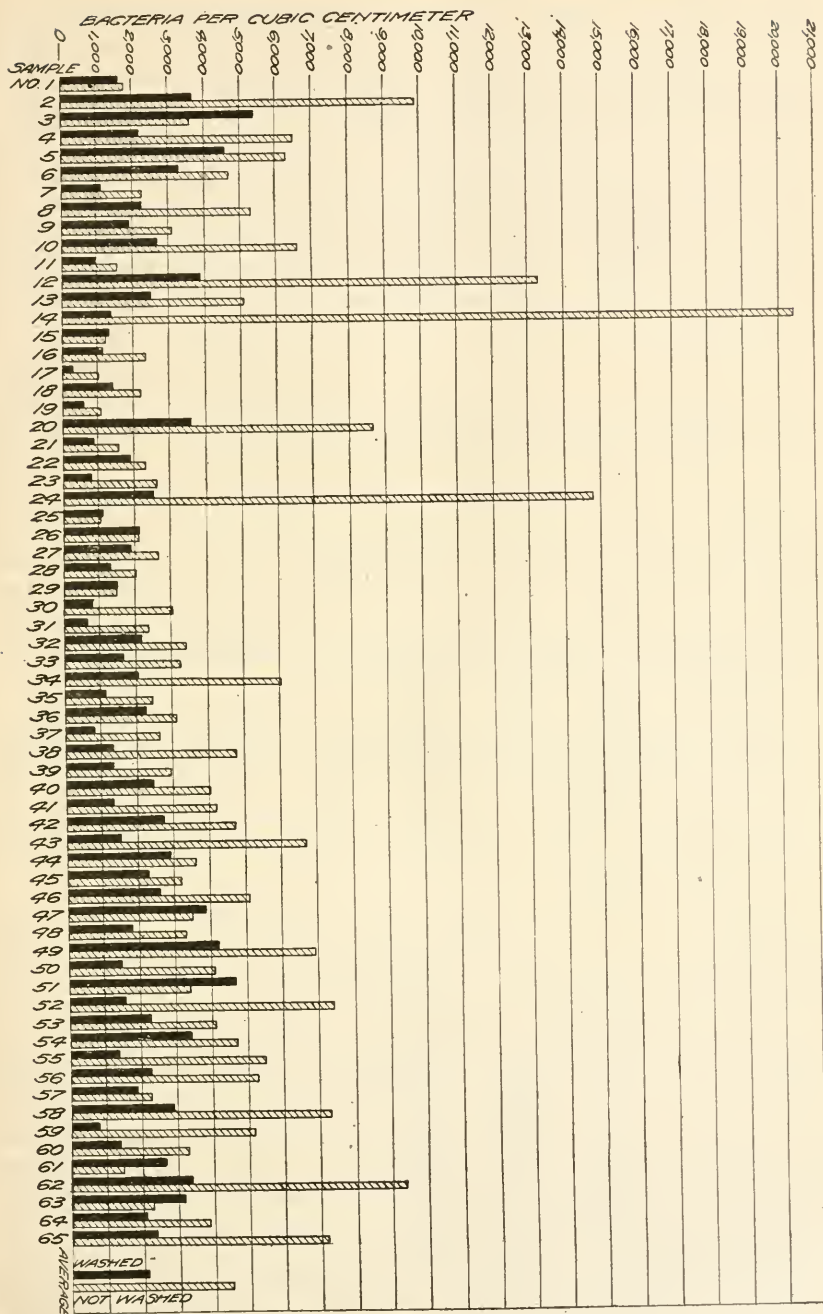


FIG. 10.—Effect of washing the udder and teats on the bacterial content of milk.

almost always a lower count than that from the unwashed udders. The results again lead to the conclusion, as in Experiment No. 3, that three simple factors are necessary for the production of milk practically free from visible dirt and with a low bacterial content when drawn, namely, sterilized utensils, clean cows (especially the udder and teats), and the small-top pail.

During Experiment No. 4 the udders of two cows were washed and two left unwashed, and frequently the practice was reversed. The change was made in order to eliminate the bacterial variation due to a difference in number of bacteria in the milk from the udder of each cow.

Occasionally the bacterial content of the middle milk drawn directly from the cow was determined, as in Experiment No. 3. The average bacterial content of such milk drawn directly from the unwashed udders was 757 per cubic centimeter, and from the washed udders 739. Subtracting these numbers from the averages shown in Table 4, there remain differences of 3,767 bacteria per cubic centimeter in the case of the unwashed udders and 1,415 in the case of the washed udders, which represent the external contamination. However, as already pointed out in connection with the previous experiment, there is probably less external contamination than the figures show.

The small additions of bacteria in milk from both washed and unwashed udders must be kept in mind, as they represent the total external contamination caused by factors formerly regarded as important but which have not been considered in these experiments in the production of low-count milk, which also was relatively free from visible sediment.

In order to show further that the fresh milk produced under such conditions was of high quality from a bacteriological standpoint and compared closely with the middle milk as drawn from the udder, the bacterial groups in a number of samples were determined by what is designated as the milk-tube method. This consisted of picking off each colony on a plate and inoculating into litmus-milk tubes. Tubes were incubated for 14 days at 30° C. (86° F.), and the bacteria from the plate were then divided into groups according to the reactions produced. By that method it was possible to divide the bacteria developing on a plate into 6 groups, namely, the acid-forming, coagulating-acid forming, the inert (which produce no change in milk), the alkali-forming, the peptonizing, and the acid-coagulating peptonizing groups. A number of samples of milk were studied by that method, and as often as possible samples were taken directly from the udder at the same milking. The results of the

work, showing the per cent of the various groups found in the regular milk and the corresponding samples of middle milk directly from the udder, are shown in Table 5. It is interesting to note that the average per cent of the bacterial groups in the milk checks very closely with the average of those in the milk taken directly from the udder. Taking the bacterial groups and counts into consideration, it seems evident that milk produced under the conditions of the experiment was of a high quality from a bacteriological standpoint and was very similar to that taken directly from the udder of the cow. The results of the experiment agree closely with those obtained by North (2), who found it possible to produce low-count milk by the use of small-top, sterilized pails in an old barn.

TABLE 5.—A comparison of the bacterial groups found in clean milk of low bacterial count and in milk directly from the udder.

BACTERIAL GROUPS IN MILK SAMPLES.

Date.	Sample No.	Acid coagulating.	- Acid.	Inert.	Alkali.	Peptonizing.	Acid coagulating (peptonizing).
1916.		<i>Per cent.</i>	<i>Per cent.</i>	<i>Per cent.</i>	<i>Per cent.</i>	<i>Per cent.</i>	<i>Per cent.</i>
Feb. 29.....	9	44.45	12.96	25.92	0	0	16.67
Feb. 29.....	10	0	57.14	37.14	0	5.72	0
Mar. 1.....	11	47.62	4.76	14.29	0	0	33.33
Mar. 1.....	12	0	17.56	75.68	0	6.76	0
Mar. 3.....	19	69.40	10.39	14.75	0	0	5.46
Mar. 17.....	66	63.06	5.09	17.19	.64	11.48	2.54
Mar. 24.....	91	7.00	85.00	3.00	2.00	3.00	0
Mar. 24.....	92	75.30	10.24	11.44	3.02	0	0
Average.....		38.36	25.39	24.93	.64	3.37	7.25

BACTERIAL GROUPS IN MILK DIRECTLY FROM THE UDDER.

Date.	Cow No.	Acid coagulating.	Acid.	Inert.	Alkali.	Peptonizing.	Acid coagulating (peptonizing).
1916.		<i>Per cent.</i>	<i>Per cent.</i>	<i>Per cent.</i>	<i>Per cent.</i>	<i>Per cent.</i>	<i>Per cent.</i>
Feb. 29.....	2	19.00	39.00	36.00	1.00	5.00	0
Feb. 29.....	23	0	97.81	0	0	2.19	0
Feb. 29.....	26	82.86	8.57	8.57	0	0	0
Mar. 9.....	2	28.04	64.02	3.27	0	4.67	0
Mar. 9.....	23	5.11	87.66	3.83	0	0	3.40
Mar. 9.....	26	85.71	14.29	0	0	0	0
Mar. 16.....	2	68.34	12.08	5.00	0	0	14.58
Mar. 16.....	23	2.94	88.82	1.18	0	0	7.06
Mar. 16.....	26	77.09	0	2.08	0	2.08	18.75
Mar. 24.....	23	5.78	72.83	14.46	1.73	1.73	3.47
Mar. 24.....	26	64.58	16.67	16.67	0	2.08	0
Average.....		39.95	45.61	8.28	.25	1.61	4.29

EXPERIMENT NO. 5. (COWS AND FLOOR DIRTY, MANURE REMOVED WEEKLY, UTENSILS STERILIZED.)

This experiment was conducted under the same conditions as Experiment No. 2. Having determined the essential factors necessary for the production of fresh milk of low bacterial content, it was considered advisable to reproduce the original conditions in order to check the three factors again. Consequently, in the experiment the cows were allowed to get dirty and the manure was removed only once a week, but the other conditions of the barn were not changed. The object was to determine the factor of dirty cows; therefore, the utensils were sterilized in order not to add another factor. The condition of the barn and of the cows is illustrated in figures 11 and 12, respectively. Particular attention is directed to the extremely large quantity of filth on the floor of the barn.

During the experiment, which continued from April 11 to May 6, 1916, 41 samples of milk were examined from both small-top and open pails. The average count of samples from the former was 24,439, and from the latter 86,212 bacteria per cubic centimeter, as shown in Table 6.

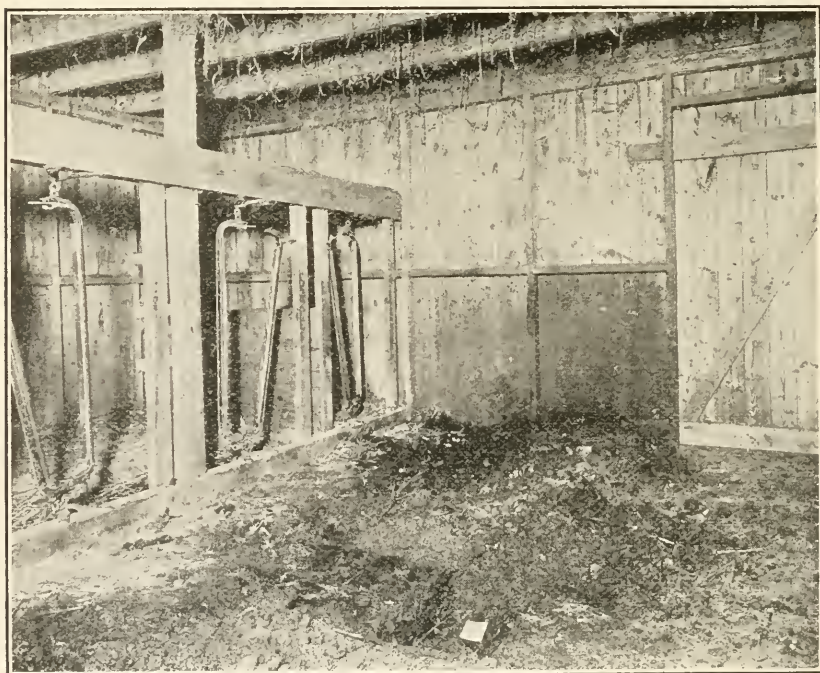


FIG. 11.—Condition of barn during Experiment No. 5.

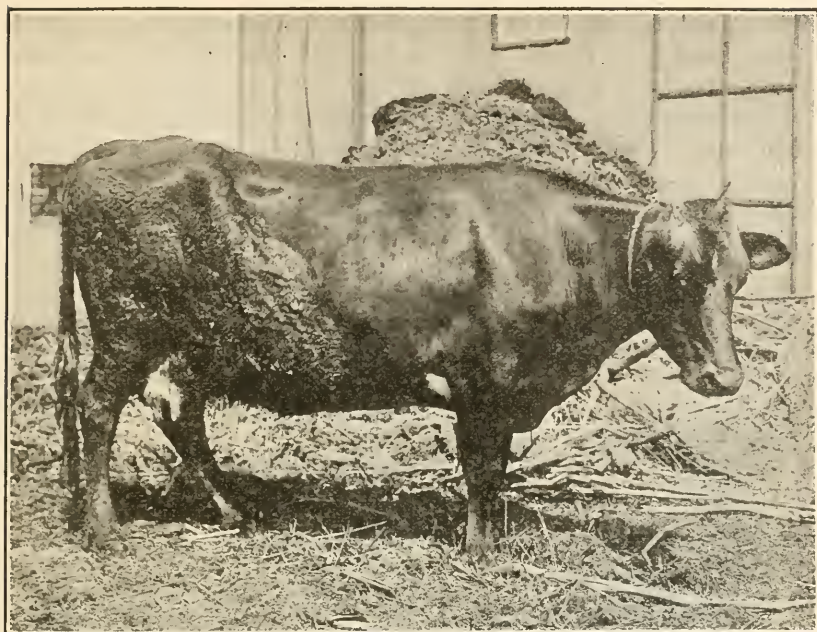


FIG. 12.—Condition of one of the cows during Experiment No. 5.

TABLE 6.—*Bacteria per cubic centimeter in dual samples of fresh milk produced under conditions described in Experiment No. 5.*

Date.	Sample No.	Open pail.	Small-top pail.	Date.	Sample No.	Open pail.	Small-top pail.
1916.				1916.			
Apr. 11, a. m.	1	10,600	4,300	Apr. 26, a. m.	23	19,600	7,500
Apr. 11, p. m.	2	4,500	4,800	Apr. 26, p. m.	24	5,600	3,500
Apr. 12, a. m.	3	8,100	5,600	Apr. 27, a. m.	25	69,000	7,200
Apr. 12, p. m.	4	2,406	2,500	Apr. 27, p. m.	26	9,400	1,900
Apr. 13, a. m.	5	13,900	10,800	Apr. 28, a. m.	27	66,000	17,700
Apr. 13, p. m.	6	6,400	6,100	Apr. 28, p. m.	28	10,800	1,900
Apr. 14, a. m.	7	165,000	26,900	Apr. 29, a. m.	29	53,000	31,000
Apr. 14, p. m.	8	360,000	105,000	Apr. 29, p. m.	30	29,000	3,500
Apr. 15, a. m.	9	240,000	29,800	May 1, p. m.	31	15,900	7,300
Apr. 17, a. m.	10	83,000	14,600	May 2, a. m.	32	8,900	6,100
Apr. 17, p. m.	11	112,000	31,300	May 2, p. m.	33	8,100	2,800
Apr. 18, a. m.	12	65,000	19,700	May 3, a. m.	34	16,100	10,200
Apr. 18, p. m.	13	58,000	18,200	May 3, p. m.	35	3,500	13,100
Apr. 19, a. m.	14	121,000	78,000	May 4, a. m.	36	4,100	8,400
Apr. 19, p. m.	15	144,000	21,100	May 4, p. m.	37	2,600	3,100
Apr. 20, a. m.	16	276,000	122,000	May 5, a. m.	38	65,000	23,000
Apr. 20, p. m.	17	112,000	72,000	May 5, p. m.	39	11,500	6,600
Apr. 21, a. m.	18	163,000	79,000	May 6, a. m.	40	61,000	10,900
Apr. 24, a. m.	19	940,000	166,000	May 6, p. m.	41	11,400	3,700
Apr. 24, p. m.	20	158,000	9,600	Average.....		86,212	24,439
Apr. 25, a. m.	21	16,500	3,200				
Apr. 25, p. m.	22	4,800	2,100				

If the average bacterial counts in the experiment are compared with those in Table 2, a similar experiment, it will be seen that the average count from the small-top pail was 24,439 in one series and 17,027 in the other. The open pail showed a greater variation, being 86,212 in one case and 22,677 in the other. In the last series with the open pail (Table 6) there are a few high counts which

raise the average greatly. The figures are of interest because with similar barn conditions, dirty cows, and the manure removed weekly, practically the same average number of bacteria were introduced at periods of time which were about six months apart. The results again show that the number of bacteria introduced through manure was not so large as had been expected.

An examination of Table 6 shows the value of the small-top pail, which is most strikingly shown in graphic form in figure 13.

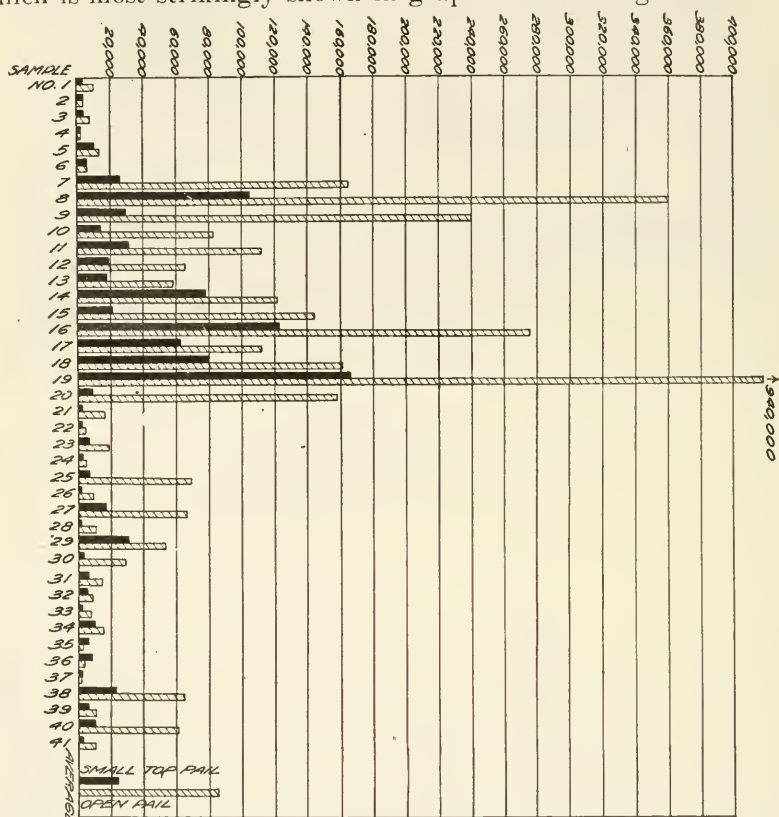


FIG. 13.—Bacterial content of milk from sterilized small-top and open pails during Experiment No. 5.

EXPERIMENT NO. 6. (COWS AND FLOORS DIRTY, MANURE REMOVED WEEKLY, UTENSILS NOT STERILIZED.)

The conditions of this experiment were similar to those of Experiment No. 1. Table 7, covering the period from May 8 to 31, 1916, shows the average count of 36 samples of milk from the small-top pail to be 114,497, compared with 153,905 bacteria per cubic centimeter for the open pail. A comparison of the averages with those in Experiment No. 1, results of which are given in Table 1, shows that the counts in the latter experiment were considerably higher, which may be explained by the variable bacterial content of unsterilized utensils.

TABLE 7.—*Bacteria per cubic centimeter in dual samples of fresh milk produced under conditions described in Experiment No. 6.*

Date.	Sample No.	Open pail.	Small-top pail.	Date.	Sample No.	Open pail.	Small-top pail.
1916.				1916.			
May 8, a. m.	1	149,000	55,000	May 22, p. m.	20	168,000	125,000
May 9, p. m.	2	53,000	12,200	May 23, a. m.	21	202,000	230,000
May 10, a. m.	3	22,500	18,100	May 23, p. m.	22	279,000	201,000
May 11, p. m.	4	39,000	19,500	May 24, a. m.	23	332,000	265,000
May 12, a. m.	5	6,800	12,400	May 24, p. m.	24	227,000	148,000
May 12, p. m.	6	36,300	6,100	May 25, a. m.	25	215,000	168,000
May 13, a. m.	7	108,000	71,000	May 25, p. m.	26	198,000	86,000
May 13, p. m.	8	48,000	40,000	May 26, a. m.	27	209,000	157,000
May 15, a. m.	9	82,000	193,000	May 26, p. m.	28	181,000	78,000
May 15, p. m.	10	31,000	56,000	May 27, a. m.	29	176,000	186,000
May 16, a. m.	11	115,000	169,000	May 27, p. m.	30	196,000	93,000
May 16, p. m.	12	126,000	166,000	May 29, a. m.	31	256,000	128,000
May 17, a. m.	13	207,000	210,000	May 29, p. m.	32	240,000	312,000
May 17, p. m.	14	151,000	42,000	May 30, a. m.	33	338,000	161,000
May 18, a. m.	15	154,000	68,000	May 30, p. m.	34	191,000	94,000
May 18, p. m.	16	99,000	74,000	May 31, a. m.	35	99,000	74,000
May 19, a. m.	17	167,000	94,000	May 31, p. m.	36	94,000	63,000
May 21, p. m.	18	126,000	87,600				
May 22, a. m.	19	216,000	159,000	Average.....		153,905	114,497

In all the experiments the utensils were probably washed more carefully than on the average farm, and to show how many bacteria may be introduced into milk under dirty conditions when utensils are not washed until just before milking, figures from another series of experiments may be of interest. In the latter experiments milk produced with the use of the small-top pails showed an average count of 1,309,000 compared with 2,015,000 bacteria per cubic centimeter in open pails. While in this experiment utensils were handled in an extremely careless manner, the results show that a large number of bacteria may be introduced from unsterilized utensils.

While the average count from the open pail was higher than from the small-top pail, the value of the latter can not be accurately determined from the results, because the utensils were not sterilized. In a general way, however, the small-top pail has some value even under the conditions described.

The results obtained in Experiment No. 6 confirm those obtained in our first experiment and indicate that the greatest contamination of milk comes from the use of unsterilized utensils.

EXPERIMENT NO. 7. (COWS AND FLOOR CLEAN, MANURE REMOVED DAILY, UDDERS AND TEATS OF COWS WASHED, UTENSILS STERILIZED.)

Experiment No. 7 was conducted under the same conditions as Experiment No. 4 except that the cows were not bedded. The general condition of the barn during the experiment is illustrated in figure 14 and that of the cows in figure 15. The floor of the stable was kept comparatively clean, the manure was removed daily, the utensils were sterilized, and at each milking the cows were cleaned and udders and teats were wiped with a damp cloth. Only a few samples of milk were taken during this experiment, which continued

from June 5 to 15, 1916. The average bacterial count of 15 samples from the small-top pail was 2,667 and from the open pail 4,947 bacteria per cubic centimeter, as shown in Table 8. In the previous series (Table 4) the average bacterial count was 2,154, compared with 2,667, the average count obtained in this series. The figures are particularly interesting, as they represent average counts of milk produced under similar conditions with periods of time about three months apart. The bacterial counts of milk from the small-top compared with open pails again show the value of the former type.

TABLE 8.—*Bacteria per cubic centimeter in dual samples of fresh milk produced under conditions described in Experiment No. 7.*

Date.	Sample No.	Open pail.	Small-top pail.	Date.	Sample No.	Open pail.	Small-top pail.
1916.				1916.			
June 5, p. m.....	1	4,900	1,300	June 10, a. m.....	10	3,100	2,300
June 6, a. m.....	2	21,300	1,200	June 10, p. m.....	11	8,400	1,600
June 6, p. m.....	3	3,700	6,400	June 12, a. m.....	12	3,800	5,400
June 7, a. m.....	4	3,100	2,300	June 12, p. m.....	13	1,700	4,600
June 7, p. m.....	5	4,900	2,200	June 13, a. m.....	14	1,500	2,100
June 8, a. m.....	6	3,700	1,400	June 13, p. m.....	15	900	2,200
June 8, p. m.....	7	2,800	2,400	Average.....		4,947	2,667
June 9, a. m.....	8	7,500	3,300				
June 9, p. m.....	9	2,900	1,300				



FIG. 14.—Condition of barn during Experiment No. 7.

During this experiment the average count of the middle milk taken directly from the udder of two cows was 1,172 bacteria per cubic centimeter, which, subtracted from 2,667, the count of the entire milking which was milked into small-top pails, leaves 1,495, or the number of bacteria per cubic centimeter introduced into the small-top pail by external contamination.

Similarly the average udder count of middle milk of the two cows milked into open pails was 1,557, which, when subtracted from the average of the open pail, 4,947, gives a difference of 3,390 bacteria per cubic centimeter to represent the number introduced by external contamination.

In this final experiment we again used a few simple factors, namely, sterilized utensils, clean cows with clean udders and teats, and the small-top pail. The figures confirm the previous results.

CONTAMINATION OF MILK BY UNSTERILIZED UTENSILS.

In this work the results have indicated that generally the greatest contamination of milk comes from the use of unsterilized utensils. Since that factor is so important in the production of low-count milk it deserves special consideration, and therefore additional data on the subject are presented.

Table 9 shows the results of the bacterial examination of 60 samples of milk from both sterilized and unsterilized small-top pails. Each number represents two samples taken at the same milking, when two cows were milked into a sterilized pail and two into an unsterilized one. All the cows were cleaned and bedded, but the udders were not washed. The 60 samples from the sterilized pail showed an average bacterial count of 6,306, compared with 73,308 for the unsterilized pail, a difference of 67,002, which represents the average number of bacteria per cubic centimeter introduced through unsteril-



FIG. 15.—Condition of the flank and udder of one of the cows during Experiment No. 7.

ized utensils. The results appear graphically in figure 16, which shows the remarkable difference between the bacterial content of milk from sterilized and unsterilized utensils. The highest bacterial count of all the samples from sterilized utensils was 21,500 and from unsterilized utensils 284,000 bacteria per cubic centimeter.

TABLE 9.—*Bacteria per cubic centimeter in dual samples of fresh milk when sterilized and unsterilized utensils were used.*

Date.	Sam- p'c No.	Small-top pail.		Date.	Sam- ple No.	Small-top pail.	
		Steril- ized.	Unsteril- ized.			Steril- ized.	Unsteril- ized.
1916.				1916.			
Jan. 19, p. m.	1	3 700	17,500	Feb. 8, a. m.	32	16,700	56,000
Jan. 20, a. m.	2	5,800	112,000	Feb. 8, p. m.	33	2,900	37,000
Jan. 20, p. m.	3	6,900	47,600	Feb. 9, a. m.	34	6,800	18,300
Jan. 21, a. m.	4	12,500	38,200	Feb. 9, p. m.	35	1,200	149,000
Jan. 21, p. m.	5	4,900	18,400	Feb. 10, a. m.	36	3,100	42,000
Jan. 23, p. m.	6	8,100	126,000	Feb. 10, p. m.	37	1,500	42,500
Jan. 24, a. m.	7	3,300	68,000	Feb. 11, a. m.	38	5,400	37,100
Jan. 24, p. m.	8	6,900	9,700	Feb. 11, p. m.	39	2,900	94,000
Jan. 25, a. m.	9	3,800	96,000	Feb. 12, a. m.	40	6,300	33,900
Jan. 25, p. m.	10	4,200	16,500	Feb. 13, p. m.	41	2,500	21,200
Jan. 26, a. m.	11	6,800	85,000	Feb. 14, p. m.	42	4,200	19,800
Jan. 26, p. m.	12	6,600	18,600	Feb. 15, a. m.	43	12,500	55,200
Jan. 27, a. m.	13	21,500	27,900	Feb. 15, p. m.	44	7,500	68,000
Jan. 27, p. m.	14	4,500	5,100	Feb. 16, a. m.	45	4,500	.....
Jan. 28, a. m.	15	4,900	48,500	Feb. 16, p. m.	46	1,500	117,000
Jan. 28, p. m.	16	3,700	141,000	Feb. 17, a. m.	47	6,300	195,000
Jan. 29, a. m.	17	7,800	54,000	Feb. 17, p. m.	48	3,100	65,000
Jan. 30, p. m.	18	3,400	203,000	Feb. 18, a. m.	49	6,900	152,000
Jan. 31, a. m.	19	17,500	98,600	Feb. 18, p. m.	50	8,900	103,000
Jan. 31, p. m.	20	2,600	102,000	Feb. 19, a. m.	51	8,500	106,000
Feb. 1, a. m.	21	15,800	64,700	Feb. 20, p. m.	52	5,800	62,000
Feb. 1, p. m.	22	9,300	92,000	Feb. 22, p. m.	53	2,500	83,000
Feb. 2, p. m.	23	3,500	97,000	Feb. 23, a. m.	54	6,200	39,700
Feb. 3, a. m.	24	5,100	32,200	Feb. 23, p. m.	55	6,200	97,000
Feb. 3, p. m.	25	3,000	28,200	Feb. 24, a. m.	56	8,900	97,000
Feb. 4, a. m.	26	9,900	7,400	Feb. 24, p. m.	57	5,100	133,000
Feb. 4, p. m.	27	2,700	37,500	Feb. 25, a. m.	58	3,900	130,000
Feb. 5, a. m.	28	19,300	11,800	Feb. 25, p. m.	59	4,600	131,000
Feb. 6, p. m.	29	2,600	284,000	Feb. 26, a. m.	60	3,200	134,000
Feb. 7, a. m.	30	5,300	54,000				
Feb. 7, p. m.	31	2,900	68,000	Average.....	.....	6,306	73,308

The diagram shows that in two cases, numbers 26 and 28, the milk from the sterilized utensils was slightly higher in bacterial content than that from the unsterilized. In both cases the counts were relatively low, which indicates that the unsterilized utensils in these particular cases were thoroughly washed in very hot water. Throughout the series, as soon as the samples were taken the pails and cans were washed in hot water—54.4° C. (130° F.)—in which washing powder had been dissolved. The insides of the cans and pails were scrubbed with a brush. After washing, the cans were inverted and remained uncovered until the next milking. It is evident that they were washed better than they would have been on the average farm. By this method of handling it is apparent that the number of bacteria in the unsterilized cans would be smaller than in those in which milk had stood for a considerable time, for in the latter case there is an opportunity for a great multiplication of bacteria. The higher the bac-

terial count in the milk, the higher it would be in the can after the milk is poured out. The more milk there is left in the can before washing, the higher the count would probably be after washing, and consequently the greater the contamination of the fresh milk placed in the can. The method of handling utensils in the experiment ex-

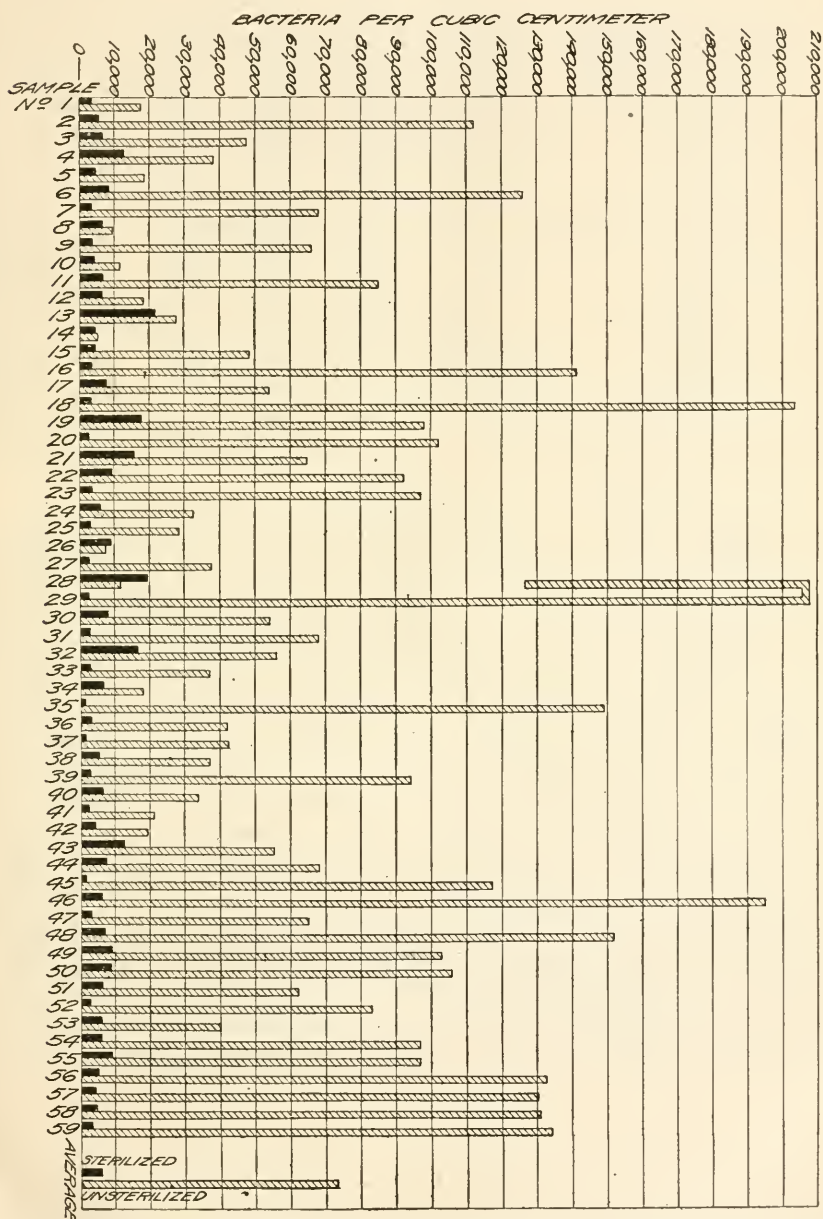


FIG. 16.—Bacterial contents of milk from sterilized (black) and unsterilized (white) utensils.

plains, therefore, the relatively low count found in milk placed in the unsterilized utensils.

The number of bacteria introduced into milk by unsterilized utensils is extremely variable because of the many different ways in which the utensils may be handled. To show the variation other experiments were conducted, the results of which are shown in Table 10. In these experiments the manure was removed only twice a week and the cows were dirty. Under the conditions the average count of 30 samples of milk from sterilized utensils was 31,040 bacteria per cubic centimeter, which represents the contamination of the milk, largely by manure, but does not include that from unsterilized utensils. Under the same conditions 50 samples of milk were taken, directly after milking, from washed but not sterilized utensils. The average count of this series of samples was 666,520. Deducting 31,040, the average count from sterilized utensils, the remainder, 635,480, represents the average bacterial contamination per cubic centimeter of milk resulting from unsterilized utensils. Referring to the contamination by unsterilized utensils discussed in the previous experiment and shown in Table 9, it may be seen that the contamination in the two experiments was very different, being in the former relatively low and in the latter very high.

To show further the variability of the factor of unsterilized utensils, another series of samples was examined under the same barn conditions but with utensils treated in a different manner. After milking, the milk was poured from the utensils, but the drainings were allowed to remain. The utensils were placed upright on the floor until the next milking, or about eight hours later, when they were washed in the same manner as in the previous experiments. The 20 samples of milk taken under these conditions averaged 1,667,000 bacteria per cubic centimeter, as shown in Table 10. The count was nearly three times that of the average of 50 samples in which the utensils were washed immediately after milking but not sterilized. By deducting the average figure of 31,040 bacteria obtained in the samples from sterilized utensils, the average number introduced from unsterilized ones held eight hours before washing was about 1,635,000 bacteria per cubic centimeter. While that method of handling utensils may not represent average conditions in practice, it is not unusual. The results indicate that a very large number of bacteria may be introduced into milk from washed, unsterilized utensils.

TABLE 10.—*Number of bacteria per cubic centimeter introduced into milk through unsterilized utensils.*

Sample No.	Utensils sterilized.	Utensils washed directly after milking.	Utensils held 8 hours before washing.	Sample No.	Utensils sterilized.	Utensils washed directly after milking.	Utensils held 8 hours before washing.
1.....	27,000	225,000	670,000	27.....	24,500	1,310,000	.....
2.....	58,000	1,140,000	820,000	28.....	25,000	520,000	.....
3.....	54,000	270,000	3,300,000	29.....	16,500	750,000	.....
4.....	83,000	620,000	1,800,000	30.....	10,500	460,000	.....
5.....	28,000	680,000	1,170,000	31.....	.....	320,000	.....
6.....	96,000	1,080,000	1,440,000	32.....	.....	440,000	.....
7.....	11,800	490,000	620,000	33.....	.....	180,000	.....
8.....	39,000	850,000	860,000	34.....	.....	490,000	.....
9.....	23,600	840,000	570,000	35.....	.....	318,000	.....
10.....	98,000	1,450,000	630,000	36.....	.....	497,000	.....
11.....	21,600	2,400,000	1,300,000	37.....	.....	580,000	.....
12.....	12,400	1,950,000	2,720,000	38.....	.....	440,000	.....
13.....	10,200	260,000	1,120,000	39.....	.....	780,000	.....
14.....	22,000	610,000	1,840,000	40.....	.....	710,000	.....
15.....	12,100	340,000	1,080,000	41.....	.....	590,000	.....
16.....	42,000	630,000	1,920,000	42.....	.....	310,000	.....
17.....	16,400	179,000	1,160,000	43.....	.....	450,000	.....
18.....	22,800	366,000	3,820,000	44.....	.....	230,000	.....
19.....	24,000	304,000	2,200,000	45.....	.....	190,000	.....
20.....	37,000	460,000	4,300,000	46.....	.....	230,000	.....
21.....	13,500	1,320,000	.....	47.....	.....	182,000	.....
22.....	57,000	790,000	.....	48.....	.....	340,000	.....
23.....	14,200	1,600,000	.....	49.....	.....	560,000	.....
24.....	15,500	295,000	.....	50.....	.....	670,000	.....
25.....	8,000	1,910,000	.....				
26.....	7,600	690,000	.....				
				Average....	31,040	666,520	1,667,000

Several determinations of the total number of bacteria in washed cans and pails were made just before milking. They were obtained as follows: Four hundred cubic centimeters of sterile water was placed in each utensil and vigorously shaken, the contents were then poured into a sterile receptacle and the number of bacteria determined in the usual way. The results of some of the determinations are shown in Table 11. Five-gallon cans were washed, as has been described, with hot water at approximately 54.4° C. (130° F.) in which washing powder was dissolved. The interior of the utensils was scrubbed with a brush, then rinsed, inverted, and left uncovered in the milk house. The number of bacteria per can ranged from 292,000,000 to 5,520,000,000 and in the pails from 2,400 to 12,600,000. Table 11 also shows two counts of pails and cans which had been held eight hours before being washed, one can showing 15,600,000,000 and the other 16,800,000,000 bacteria, while the pails showed 44,000,000 and 700,000,000 bacteria, respectively. The results show the great variation that may occur in can and pail counts when held under different conditions.

TABLE 11.—*Total number of bacteria found in clean-washed but unsterilized utensils.*

Series No.	Washed can.	Washed pail.	Series No.	Washed can.	Washed pail.
1.....	728,000,000	76,400	8.....	292,000,000	4,200,000
2.....	816,000,000	2,600	9.....	1,220,000,000	652,000
3.....	860,000,000	2,400	10.....	1,180,000,000	2,200,000
4.....	5,520,000,000	17,600	11.....	1,640,000,000	10,400,000
5.....	624,000,000	8,800	12.....	¹ 16,800,000,000	¹ 700,000,000
6.....	870,000,000	12,600,000	13.....	¹ 15,600,000,000	44,000,000
7.....	1,580,000,000	1,380,000			

¹ Held 8 hours before washing.

During the work it was thought that one rinsing of a can with sterile water probably did not remove all the bacteria from the interior. To determine the point several tests were made, the results of which are shown in Table 12. In the first test the can was rinsed twice, with 400 cubic centimeters of sterile water each time. The first rinsing showed 860,000,000 bacteria and the second 478,800,000, or a total of 1,338,800,000 bacteria in the can. In a second test, in which the can was rinsed three times, each rinsing showed large numbers of bacteria, the count being lower after each rinsing. In a third test, in which four rinsings were made, the last one still removed a large number of bacteria. It follows from these results that one rinsing removes only a portion of the bacteria from the can, and therefore is not a true measure of the number of bacteria present. The highest total count per 5-gallon can in that test was 8,876,000,000 bacteria. A simple calculation proves that if this can were filled with milk, 469,132 bacteria would be added to each cubic centimeter through contamination from the can. This merely shows the possibility of great contamination from unsterilized utensils.

TABLE 12.—*Effect of several rinsings in determining the number of bacteria in cans.*

Number of rinsing.	Number of bacteria per washed can.
1.....	860,000,000
2.....	478,800,000
Total.....	1,338,800,000
1.....	5,520,000,000
2.....	2,640,000,000
3.....	716,000,000
Total.....	8,876,000,000
1.....	624,000,000
2.....	316,000,000
3.....	109,000,000
4.....	72,000,000
Total.....	1,121,000,000

As a matter of additional interest, some experiments were conducted which show that bacteria grow in washed cans which are closed before they are thoroughly dried. To illustrate the point, two 5-gallon cans were sterilized, then one was filled with milk, which was immediately poured into the other, and that in turn immediately emptied. The operation was performed in order to introduce into each can approximately the same number of bacteria. Each can was then washed in exactly the same manner, the excess of water being shaken out and the cover replaced. A determination of the number of bacteria in one of the freshly washed cans was then made. The other can, which it may be assumed contained approximately the same number of bacteria at that time, was allowed to stand at a warm temperature for 24 hours, when the number of bacteria was determined. An examination of the results in Table 13 shows that in each of the seven tests there was a great increase in the number of bacteria in the cans during the holding period of 24 hours. The importance of drying cans thoroughly after washing, particularly when they are immediately covered, is therefore evident.

TABLE 13.—*Bacterial growth in cans covered before being dried.*

Series No.	Bacteria per can.		Series No.	Bacteria per can	
	Freshly washed.	24 hours after washing.		Freshly washed.	24 hours after washing.
1.....	960,000	817,000,000	5.....	99,600	320,000,000
2.....	618,000	2,612,000,000	6.....	5,570,000	748,000,000
3.....	137,000	336,000,000	7.....	305,000	138,000,000
4.....	91,000	428,000,000			

Utensils that have not been sterilized, besides adding large numbers of bacteria to milk, introduce types which greatly affect the relation of the various bacterial groups in it. This matter also was investigated, determinations having been made of the bacterial groups in milk drawn directly from the udder, from sterilized utensils, from unsterilized utensils, and from washings of unsterilized cans. Table 14 summarizes the results of this work. Numerous samples from different sources have been averaged in the table. The bacterial groups were determined by the milk-tube method, which has been described.

The bacterial groups in the samples of milk drawn directly from the udder compare very closely with those in the milk from sterilized utensils. It will be noted that in the milk from unsterilized utensils there was a great increase in the percentage of the alkali-forming and peptonizing groups. While the acid-coagulating peptonizing group was not found in milk from utensils not sterilized, it was pres-

ent in the milk drawn directly from the udder. It was not found for the reason that the bacterial count being so great such dilutions had to be used in plating that the small number of bacteria of that type did not appear on the plates. It is also of interest to note that the washings from the unsterilized cans contained high percentages of the alkali-forming bacteria and particularly the peptonizing group. The addition of peptonizing bacteria in large numbers to milk is a matter of considerable importance, since they may be highly undesirable in that they produce putrefactive changes. North has frequently called attention to the importance of the use of sterilized utensils, which has been further emphasized by results obtained by Prucha, Harding, and Weeter (3). The work of these investigators and our own experiments indicate clearly that the use of sterilized utensils is the greatest factor in the production of milk of low bacterial count.

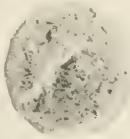
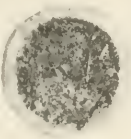
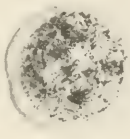
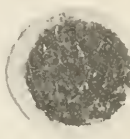
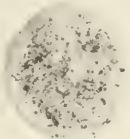
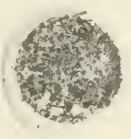
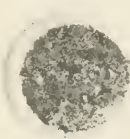
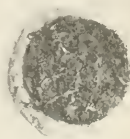
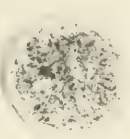
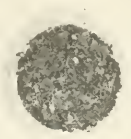
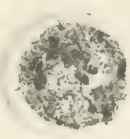
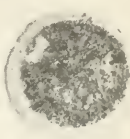
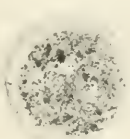
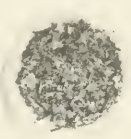
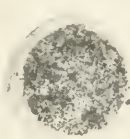
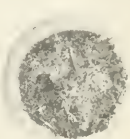
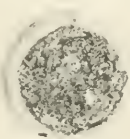
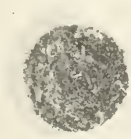
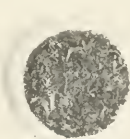
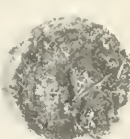
TABLE 14.—*Bacterial groups in milk directly from the udder, in fresh milk from sterilized and unsterilized utensils, and in washings from clean but unsterilized cans.*

Source of sample.	Number of samples averaged.	Bacterial groups.					
		Acid coagulating	Acid.	Inert.	Alkali.	Peptonizing.	Acid coagulating (peptonizing).
		<i>Per cent.</i>	<i>Per cent.</i>	<i>Per cent.</i>	<i>Per cent.</i>	<i>Per cent.</i>	<i>Per cent.</i>
Udder.....	47	46.21	37.25	9.41	0.45	1.36	5.09
Milk from sterilized utensils.....	19	25.81	39.22	25.51	.71	3.26	5.49
Milk from unsterilized utensils..	17	11.54	16.99	31.55	14.14	25.79	0
Washings from unsterilized cans..	2	.39	1.85	11.64	19.24	66.87	0

The small dairyman often has difficulty in providing an inexpensive apparatus for sterilizing his utensils. Realizing this, a simple steam sterilizer has been devised in the Dairy Division. The sterilizer, fully described in Farmers' Bulletin 748, entitled "A Simple Steam Sterilizer for Farm Dairy Utensils," is inexpensive to construct and operate and provides a practical method for sterilizing dairy utensils on a small scale. The bulletin will be sent free to anyone on request to the Department of Agriculture.

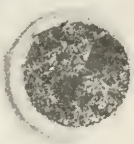
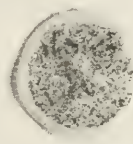
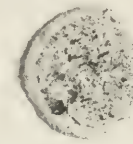
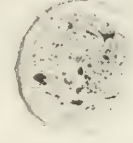
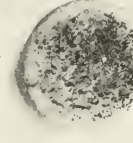
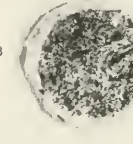
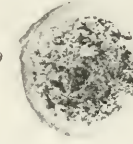
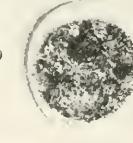
CONTAMINATION OF MILK BY MANURE AND DIRT.

It has been shown that unsterilized utensils are a source of very great contamination of milk, but they are not the only means of contamination. Statements have been made, and possibly it has been the general belief, that the greatest contamination of milk comes from manure and other accumulations of dirt on the body of the cow. The results in these experiments indicate that while that is an important source of contamination from the standpoint of the number

Small-top pail. 14,600	Open pail. 93,000	Small-top pail. 21,100	Open pail. 144,000
1 	1 	6 	6 
31,300	112,000	122,000	276,000
2 	2 	7 	7 
19,700	65,000	72,000	112,000
3 	3 	8 	8 
13,200	38,000	79,000	163,000
4 	4 	9 	9 
78,000	121,000	166,000	940,000
5 	5 	10 	10 

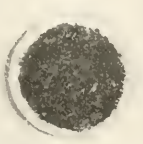
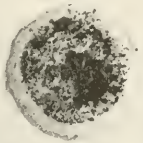
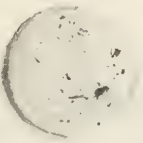
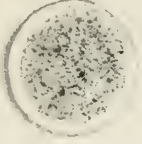
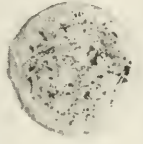
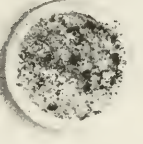
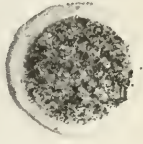
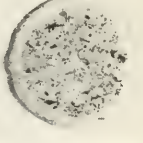
COMPARISON OF SEDIMENT AND BACTERIAL COUNT OF MILK FROM SMALL-TOP AND OPEN PAILS DURING EXPERIMENT NO. 5. BACTERIA PER CUBIC CENTIMETER AND SEDIMENT DISKS FROM ONE PINT OF MILK.

Continued in Plates II and III.

Small-top pail. 96,000	Open pail. 158,000	Small-top pail. 72 30	Open pail. 69,000
11 	11 	16 	16 
3,200	16,500	1,900	9,400
12 	12 	17 	17 
2,100	4,800	17,700	66,000
13 	13 	18 	18 
7,500	19,600	1,900	10,800
14 	14 	19 	19 
3,500	5,600	31,000	53,000
15 	15 	20 	20 

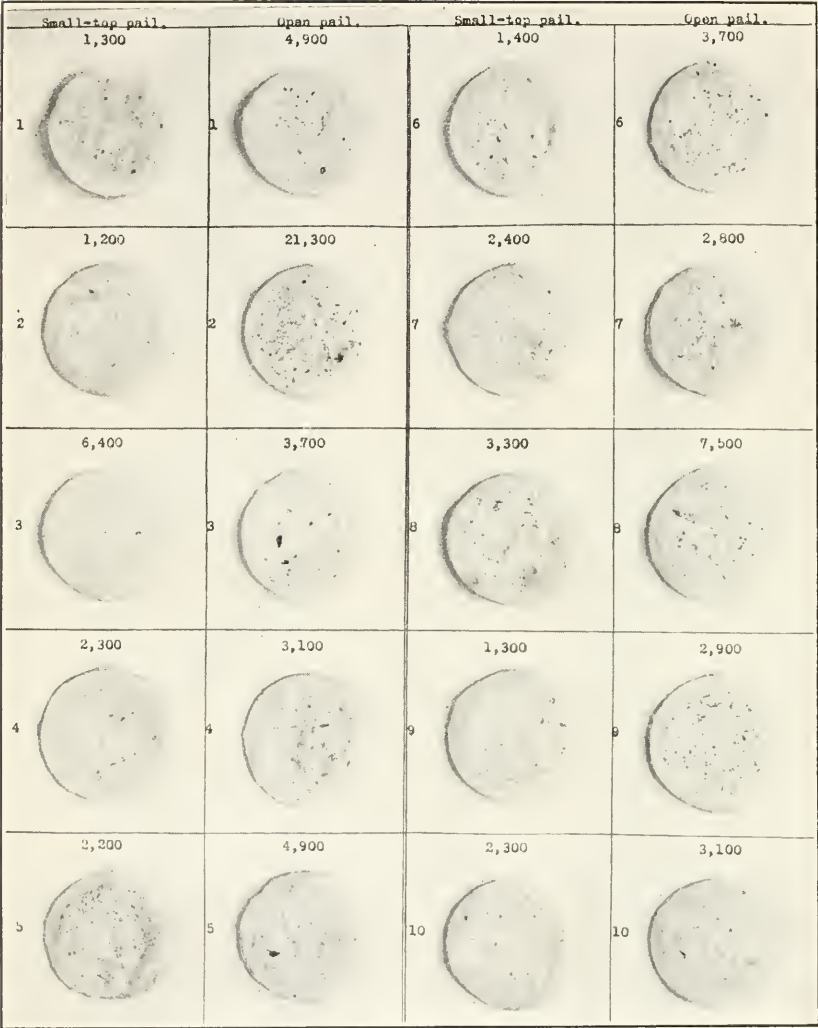
COMPARISON OF SEDIMENT AND BACTERIAL COUNT OF MILK FROM SMALL-TOP AND OPEN PAIRS DURING EXPERIMENT NO. 5. BACTERIA PER CUBIC CENTIMETER AND SEDIMENT DISKS FROM ONE PINT OF MILK.

See also Plates I and III.

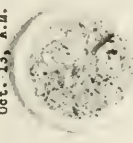
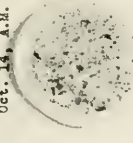
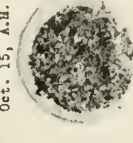
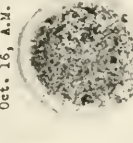
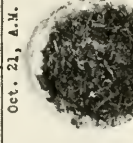
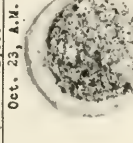
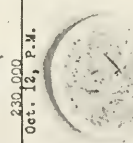
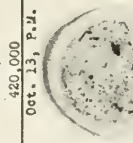
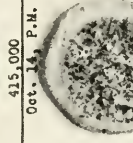
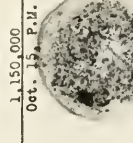
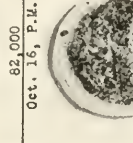
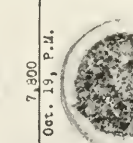
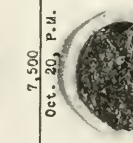
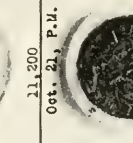
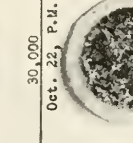
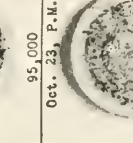
Small-top pail. 3,500	Open pail. 29,000	Small-top pail. 13,100	Open pail. 3,500
21 	21 	26 	26 
7,300	15,900	8,400	4,100
22 	22 	27 	27 
6,100	8,900	3,100	2,600
23 	23 	28 	28 
2,800	8,100	23,000	65,000
24 	24 	29 	29 
10,200	16,100	6,600	11,500
25 	25 	30 	30 

COMPARISON OF SEDIMENT AND BACTERIAL COUNT OF MILK FROM SMALL-TOP AND OPEN PAILS DURING EXPERIMENT NO. 5. BACTERIA PER CUBIC CENTIMETER AND SEDIMENT DISKS FROM ONE PINT OF MILK.

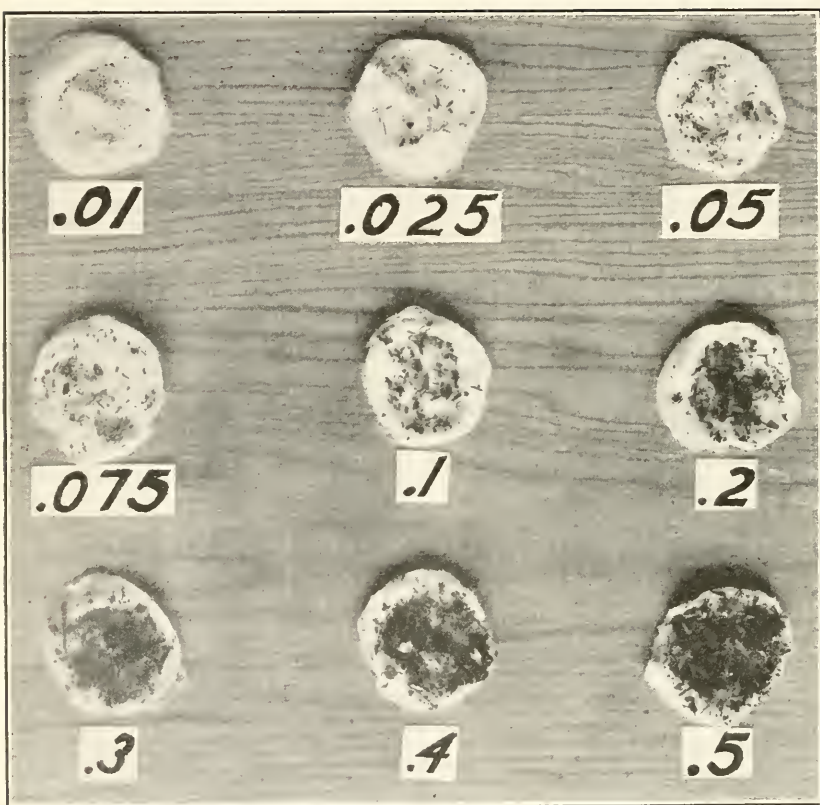
Continued from Plates I and II.



COMPARISON OF THE SEDIMENT AND BACTERIAL COUNT OF MILK FROM SMALL-TOP AND OPEN PAILS DURING EXPERIMENT NO. 7. BACTERIA PER CUBIC CENTIMETER AND SEDIMENT DISKS FROM ONE PINT OF MILK.

Oct. 12, A.M.  9,200	Oct. 13, A.M.  6,500	Oct. 14, A.M.  13,000	Oct. 15, A.M.  21,500	Oct. 16, A.M.  91,000
Oct. 19, A.M.  230,000	Oct. 20, A.M.  420,000	Oct. 21, A.M.  415,000	Oct. 22, A.M.  1,150,000	Oct. 23, A.M.  82,000
Oct. 12, P.M.  7,300	Oct. 13, P.M.  7,500	Oct. 14, P.M.  11,200	Oct. 15, P.M.  30,000	Oct. 16, P.M.  95,000
Oct. 19, P.M.  200,000	Oct. 20, P.M.  450,000	Oct. 21, P.M.  1,550,000	Oct. 22, P.M.  16,400	Oct. 23, P.M.  24,000

RELATION OF THE BACTERIAL COUNT TO THE SEDIMENT TEST. BACTERIA PER CUBIC CENTIMETER AND SEDIMENT DISKS FROM ONE PINT OF MILK.



SEDIMENT DISKS SHOWING FROM 0.01 TO 0.5 GRAM OF FRESH MANURE.

of bacteria introduced, it is a factor of less importance than unsterilized utensils. Nevertheless, dirt and manure should be kept out of milk, not only to help insure the production of milk of low bacterial count, but also to minimize the possibility of infection by disease-producing organisms, particularly that of bovine tuberculosis. It has been shown by Shroeder (4) that cattle having tuberculosis swallow their sputum, so that the tubercle bacilli in it pass through their bodies and into the manure.

The small-top pail was designed for the purpose of helping to prevent the entrance of manure and dirt into milk. Many investigations, among which may be mentioned the work of Stocking (5), also Harding (6) and his associates, and Lamson (7), have shown it to be of great assistance in this connection. Throughout the experiments both the open and small-top pails were used, and attention is again called to the value of the small-top pail in the experiments whether the cows were clean or dirty. Table 15 gives a summary of the average bacterial counts from milk from the sterilized open and small-top pails. Discussion of the results is unnecessary, as they confirm what has been recognized, namely, that lower bacterial counts can be obtained when a small-top pail is used. In all except the last figures in Table 15 the averages represent the counts at the same milking when two cows were milked into open and two into small-top pails. The most interesting point in connection with the figures is the fact that even under extremely dirty conditions relatively low average bacterial counts were obtained. The original cost of a small-top pail is little more than that of an open pail; it is no more expensive to care for and is of distinct value in preventing the entrance of manure and dirt into milk; consequently it should always be used.

TABLE 15.—*Summary of bacterial counts of milk drawn under various conditions into sterilized open and small-top pails.*

Condition of cows and barn floor.	Number of samples averaged.	Bacteria per cubic centimeter.	
		Open pail (sterilized).	Small-top pail (sterilized).
Cows dirty, manure removed once a week.....	36	22,677	17,027
Cows dirty, manure removed once a week (6 months later).....	41	86,212	24,439
Cows dirty, udders and teats clean, manure removed twice a week....	23	6,166	2,886
Cows clean, udders and teats washed, manure removed daily.....	15	4,947	2,667
Cows clean and bedded, udders not washed, manure removed daily...	32	8,681	16,306

¹ 65 samples.

The value of the small-top pail is well illustrated in Plates I, II, and III, in which a series of sediment disks is shown. The cotton disks show the sediment from milk when a small-top and an open

pail were used at the same milking; in each case the bacterial count is shown above the disk. During the work the manure was removed from the stable only twice a week, and as a result the cows were extremely dirty. A study of the disks shows that in nearly every case when the small-top pail was used there was less sediment in the milk. The most striking difference is shown in sample 21. In some samples, however, there was apparently little or no difference, and when the disks from both the small-top and open pails showed little sediment there was, as a rule, less relative difference between the disks from the two types of pails.

The average number of bacteria per cubic centimeter in the 30 samples from the small-top pail was 29,263 and in milk from the open pail 87,380. The most striking difference in the bacterial count is shown in sample 10, where samples from small-top and open pails contained a large quantity of sediment. So far as could be judged, one kind of pail contained about as much as the other, but the bacterial count of the milk from the small-top pail was 166,000 and from the open pail 940,000 bacteria per cubic centimeter. It is interesting to note that in the majority of cases in which the sediment disks showed a large quantity of manure there was a relatively low bacterial count. Occasionally a sample showed a large quantity of sediment and a high count, while other samples containing a similar amount had a low count. This is well illustrated in samples 10 and 21, which represent sediment in milk from the open pail and may be explained by the variation in the number of bacteria in samples of manure.

When the cows were clean and the udders free from visible dirt there was much less difference in the sediment in milk from the small-top and open pails, as is well illustrated in Plate IV, which shows the sediment disks of milk drawn in small-top and open pails under those conditions. The cows were kept clean, the manure was removed daily from the stable, and the udders were wiped with a damp cloth just before milking. One of the cows and the interior of the barn are shown in figures 14 and 15. It must be remembered that the sediment disks represent the sediment in unstrained milk. Of the 10 samples examined, some showed practically no difference in the quantity of sediment in milk from the small-top and open pails, but as a rule the small-top pail contained less sediment and a slightly lower bacterial content. The average number of bacteria per cubic centimeter from the small-top pail in the 10 samples was 2,410 and from the open pail 5,740. It will be noted in sample 2 that milk from the open pail showed 21,300 bacteria per cubic centimeter, which raised the average of all the samples from the open pails.

Throughout the work it was found that, in spite of the variation in the number of bacteria in manure, a fairly constant relation existed between the quantity of sediment and the bacterial count. The relation can be established only when fresh, unstrained milk, handled in sterilized utensils, is examined. Some attempts have been made by investigators to establish a relation between the sediment test and bacterial count in market milk, which, of course, has proved impossible, because the history of the milk was not known.

Campbell (8) draws the following conclusions: "The quantity of sediment or visible dirt present on the disk is no criterion as to the kind or number of bacteria contained in the milk." He made tests with samples of milk which were collected on the railroad station platform from cans as they arrived from various farmers. The conclusion is of course correct, but it should be qualified by a statement as to where the samples were taken. In such cases there are three unknown factors, namely, whether the milk was strained, whether it was handled in sterilized or unsterilized utensils, and what proportion of the bacterial count is due to contamination and what proportion due to growth. If the milk has been strained on the farm it is certain that there is no relation between the sediment and the bacterial count; neither will there be any if the milk has been handled in unsterilized utensils, which may introduce large numbers of bacteria. Neither can any relation be expected unless the comparison is made on fresh milk, since bacteria multiply rapidly unless the milk is held at a low temperature. The only way in which the relation can be established between sediment and the bacterial count is by a study of fresh, unstrained milk at the farm, and where sterilized utensils are used. Under such conditions there is a general relation between the sediment and the bacterial count, as is shown in Plate V, which shows the sediment disks from a pint of milk together with the number of bacteria per cubic centimeter in it. At the beginning of the experiment the floor in the barn was clean, the cows were fairly clean, and for a period of nine days the manure was allowed to accumulate on the floor. During that time the cows were not cleaned; consequently they became dirtier each day. The experiment began on October 12 and continued to October 23, during which time samples of milk were examined from each morning's and night's milking. The first two rows in Plate V show the sediment test and bacterial count of samples of milk at each morning's milking, the lower two rows the results from the night's milking. At the beginning, when conditions were fairly clean, it will be noted that there was a little sediment and that the bacterial count was low. On each successive day, as the cows and barn floor became dirtier, the quantity of sediment gradually increased together with the bacterial count. There were slight fluctu-

ations in the quantity of sediment as well as in the bacterial count, but on the whole there was a strikingly close relation. Plate V shows that after the morning milking on October 22 there was a decided drop in the quantity of sediment as well as in the bacterial count. On that date the manure was removed from the stable in the afternoon. That night's milk showed decidedly less sediment and a lower bacterial count, as did also both milkings of October 23. The results show that there is some direct relation between the sediment and bacterial count which always may be influenced by the variable number of bacteria in the manure. It is therefore quite evident that the sediment test is of value only under certain conditions.

Bacterial counts shown in Plate V are particularly interesting since they show that a very large quantity of sediment, in other words, manure, is necessary to create high counts provided the principal source of contamination is manure. In the experiment in which the manure was not removed nor the cows cleaned for nine days, the highest count obtained was 1,550,000, and the next highest was 1,150,000 bacteria per cubic centimeter. The other counts ranged from 6,600 to 450,000 bacteria per cubic centimeter. After the manure was removed the experiment was repeated under similar conditions for 10 days. During the latter period the highest count obtained was 82,000 and the lowest 6,600. In both experiments sterilized utensils were used; consequently, the contamination was due principally to the introduction of manure into the milk. The figures indicate that counts above 200,000 per cubic centimeter in milk usually should not be attributed entirely to contamination from manure.

The number of bacteria in 57 samples of fresh cow manure was determined, and the results are shown in Table 16. The range in number of bacteria per gram was from 2,900,000 to 690,000,000, the average number per gram being 49,645,614. From these results it can be assumed, therefore, that the average bacterial content of fresh manure is about 50,000,000 per gram. From that number it is possible to calculate the number of bacteria added to each cubic centimeter of a pint of milk through contamination by definite quantities of manure. Table 17 shows the number of bacteria that would be added to each cubic centimeter of milk if fresh manure were added in quantities varying from 0.5 to 0.01 of a gram, assuming an average gram sample to contain 50,000,000 bacteria. The figures show that 0.5 gram of fresh manure would add 52,854 bacteria to each cubic centimeter of a pint of milk, while 0.01 of a gram of manure would add 1,057.

TABLE 16.—*Number of bacteria in fresh cow manure.*

Sample No.	Bacteria per gram.	Sample No.	Bacteria per gram.	Sample No.	Bacteria per gram.	Sample No.	Bacteria per gram.
1.....	14,500,000	16.....	12,000,000	31.....	6,200,000	46.....	6,800,000
2.....	51,000,000	17.....	60,000,000	32.....	5,800,000	47.....	9,400,000
3.....	3,500,000	18.....	4,000,000	33.....	7,800,000	48.....	71,000,000
4.....	12,000,000	19.....	15,000,000	34.....	6,900,000	49.....	38,700,000
5.....	40,000,000	20.....	120,000,000	35.....	41,000,000	50.....	17,200,000
6.....	8,000,000	21.....	11,000,000	36.....	88,000,000	51.....	41,000,000
7.....	52,000,000	22.....	8,000,000	37.....	14,500,000	52.....	60,000,000
8.....	23,300,000	23.....	40,000,000	38.....	11,000,000	53.....	10,400,000
9.....	650,000,000	24.....	9,000,000	39.....	55,000,000	54.....	8,700,000
10.....	53,000,000	25.....	7,500,000	40.....	5,000,000	55.....	3,200,000
11.....	15,000,000	26.....	30,000,000	41.....	32,000,000	56.....	2,900,000
12.....	160,000,000	27.....	9,500,000	42.....	13,000,000	57.....	11,500,000
13.....	30,000,000	28.....	27,300,000	43.....	40,000,000	Average..	49,645,614
14.....	19,700,000	29.....	5,100,000	44.....	9,500,000		
15.....	690,000,000	30.....	6,000,000	45.....	26,300,000		

TABLE 17.—*Theoretical number of bacteria which may be added to milk by varying quantities of manure.*

Quantity of wet manure added to 1 pint of milk.	Number of bacteria added to each cubic centimeter of milk.
<i>Gram.</i>	
0.5	52,854
.4	42,283
.3	31,712
.2	21,141
.1	10,571
.075	7,907
.05	5,285
.025	2,642
.01	1,057

In order to show how much manure would be added to the milk, on the basis shown in Table 17, Plate VI shows a number of sediment disks.¹ It will be seen from the figure that 0.5 of a gram of wet manure represents a quantity far in excess of that found in milk as produced on an average farm, and by referring again to Table 17 it is evident that this excessive quantity of manure would add only 52,854 bacteria per cubic centimeter. If 0.1 of a gram of manure were added to a pint of milk, that quantity would add only 10,571 bacteria to each cubic centimeter.

It is realized, of course, that these figures are only relative because of the variation in the bacterial content of manure, and, furthermore, that which does enter the milk is not necessarily fresh. The figures, however, confirm former conclusions that manure, though an important source of contamination in general, is not so great a factor as unsterilized utensils in causing high bacterial counts.

¹ The authors are indebted to George B. Taylor, of the Dairy Division, for this series of disks showing definite quantities of fresh manure.

THE THREE MOST ESSENTIAL FACTORS IN THE PRODUCTION OF MILK OF LOW BACTERIAL CONTENT.

In connection with the term "production of milk" as used in this paper, it is evident that there are three essential factors which most influence the bacterial content. Named in the order of their importance they are, first, the use of sterilized utensils; second, clean cows, particularly the udders and teats; third, the use of the small-top pail. By the use of these factors it has been possible to produce milk of a low bacterial count and practically free from visible dirt in an experimental barn which represents a poor type found in this country. In fact, the counts obtained were so low that only 2,000 to 3,000 bacteria per cubic centimeter were introduced through external contamination. A large number of factors not considered in this paper are responsible for this contamination. Some of them have been extensively studied by Stocking (1), Harding (9), Ruehle (10), and Prucha (11).

It is evident, therefore, that the three simple factors mentioned prevent most of the contamination of milk. It is possible, however, that under some circumstances low-count milk can not be produced by means of these few factors. It has been shown that they prevent most of the external contamination and that by their use it is possible to produce milk with a bacterial content very nearly as low as that drawn directly from the udder. If milk drawn directly from the udder is high in bacteria, it is impossible under any conditions to produce a low-count milk.

It is well known that freshly drawn milk from some cows is sometimes high in bacteria; if there are, therefore, a number of such cows in a herd, the bacterial content of the mixed milk will be relatively high. As an example it may be well to mention a case in which milk produced in a sanitary barn from clean cows and with sterilized utensils averaged 5,096 bacteria per cubic centimeter for 28 samples. In the herd there were cows whose milk occasionally was abnormal, in that it contained a few small clots and the last milk sometimes was slightly stringy. The milk from these cows was kept separate from the regular herd milk, with the result that 28 samples of it, produced at the same time as the other samples, averaged 137,786 bacteria per cubic centimeter. It is therefore evident that with cows of that type it would be impossible under any conditions to produce a low-count milk.

It is not known how common such cows are in this country, and the point is mentioned merely to show why it is sometimes impossible, even with the three essential factors, to produce milk of low bacterial count.

The criticism may be raised that the value of the essential factors was determined under experimental conditions which do not repre-

sent practical conditions on the farm; therefore the following experiment was conducted under actual farm conditions to determine their value when used by the average dairyman.

A PRACTICAL DEMONSTRATION ON SIX FARMS.

In order to demonstrate the practical value of the three essential factors previously mentioned they were applied on six farms in the vicinity of Grove City, Pa., with the voluntary cooperation of the dairymen. Five of the farms sent milk and one sent cream to the experimental creamery operated at Grove City by the Dairy Division. It seemed advisable to have one producer of cream, in order to determine whether these factors would improve its quality.



FIG. 17.—Interior of barn at farm No. 1.

The scores of the six farms, according to the dairy-farm score card used by the Dairy Division, United States Department of Agriculture,

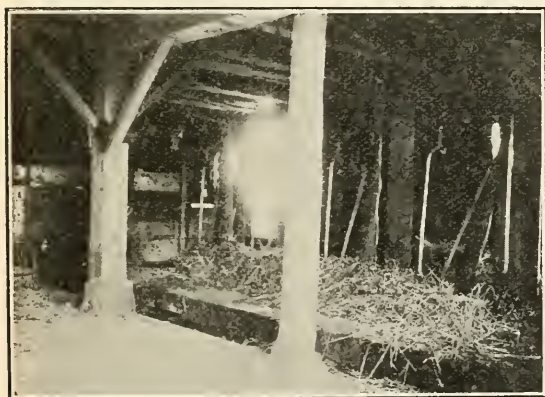


FIG. 18.—Interior of barn at farm No. 20.

were as follows: 44.1, 42, 40.5, 41.1, 40.9, and 38.4 out of a possible 100. The interiors of the barns are shown in figures 17 to 21, inclusive. The plan was to determine, first, the bacterial content of the fresh milk and cream on the farm under the existing conditions; then to place in operation the three factors,

namely, sterilized utensils, clean cows with clean udders and teats, and small-top pails.

For the work small-top pails of the type shown in figure 2 were lent to the farmers, together with simple steam sterilizers which are described in Farmers' Bulletin 748. The method of operating the

sterilizer was demonstrated to the farmers, who were then left to operate it without further assistance. As the work was carried on during the summer and the cows were in pasture most of the time,

their udders were always practically free from visible dirt; therefore that factor received no further consideration.

At each milking the milk was stirred by means of a long, sterile pipette, after which samples were taken from each can and a composite sample made, which

was immediately placed in ice water and plated within an hour and a half. For a period of three weeks samples were taken at each farm under the usual conditions (open pails, not sterilized) and for the three weeks following, when small-top pails, sterilized, were in operation.

Table 18 shows the bacterial count of each sample obtained from the night's milk, fresh, on each farm during the entire six weeks, also

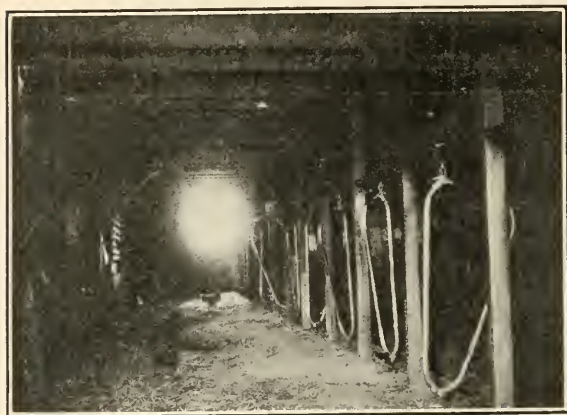


FIG. 19.—Interior of barn at farm No. 27.

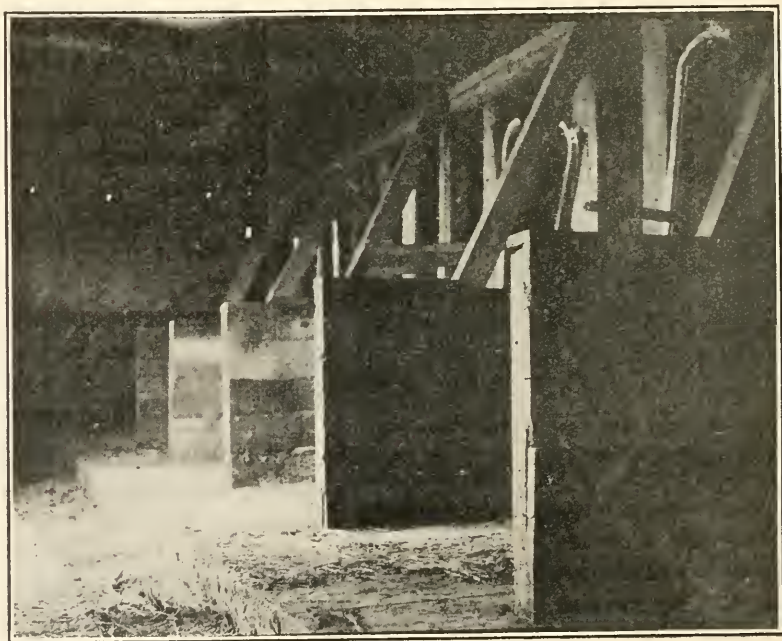


FIG. 20.—Interior of barn at farm No. 43.

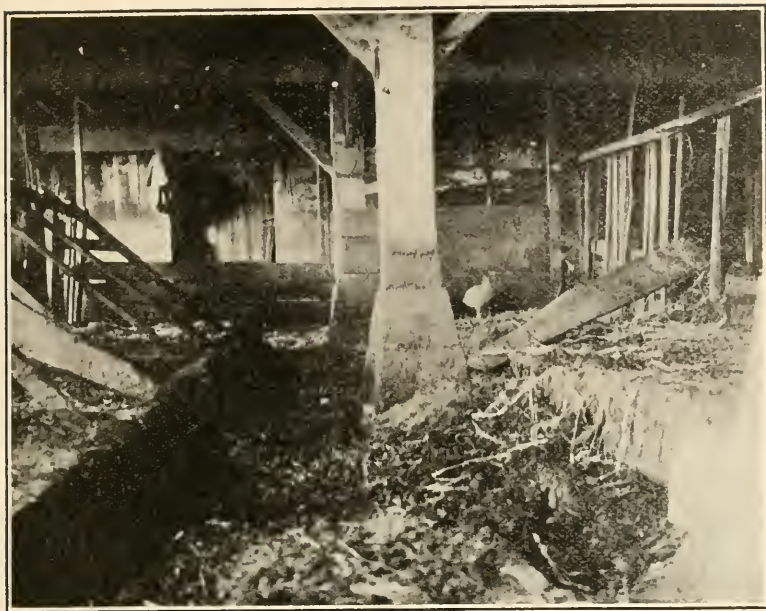


FIG. 21.—Interior of barn at farm No. 178.

the average counts. Figure 22 shows graphically the summarized and average results of the series of samples from each farm before and after the three essential factors were introduced. It will be noted that among the six farms some produced milk of a relatively low bacterial content. Milk produced from farms 20 and 43 under the ordinary conditions showed, respectively, average counts of 15,050 and 34,861 bacteria per cubic centimeter, while after the introduction of the three essential factors the count was reduced to 4,656 and 2,050, respectively. The greatest average decrease due to the intro-

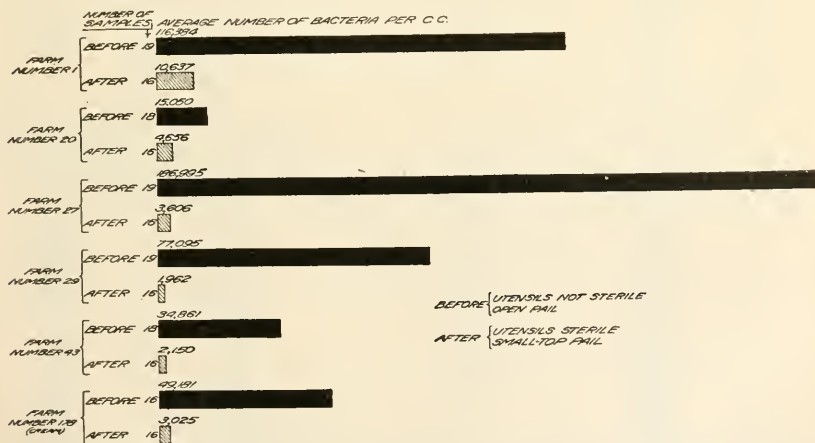


FIG. 22.—Average bacterial content of night's milk, produced on farms near Grove City, Pa., before and after using the three most essential factors for the production of milk of low bacterial content.

duction of the essential factors was noted on farm 27, where the average count was reduced from 186,995 to 3,606 bacteria per cubic centimeter. On farm 178 the average number of bacteria in the cream was reduced from 49,181 to 3,025 per cubic centimeter; all the separator parts were sterilized in the simple steam sterilizer and held in it until ready for use.

TABLE 18.—*Bacteria per cubic centimeter in daily samples of milk (5 farms) and cream (1 farm), showing effect of using small-top pails and sterilized utensils.*

Farm No.	Open pails, utensils not sterilized (3 weeks, July 23 to Aug. 12).	Small-top pails, utensils sterilized (3 weeks, Aug. 15 to Sept. 2).	Farm No.	Open pails, utensils not sterilized (3 weeks, July 23 to Aug. 12).	Small-top pails, utensils sterilized (3 weeks, Aug. 15 to Sept. 2).
1	233,000 81,000 103,000 176,000 67,000 220,000 17,300 139,000 15,200 16,900 28,500 49,000 212,000 49,000 88,000 32,300 600,000 12,600 71,000	3,500 2,700 51,300 8,500 3,200 4,100 4,500 10,000 4,100 5,000 30,000 10,000 7,600 9,000 10,800 5,900	29	80,000 109,000 65,000 8,000 16,200 80,000 8,500 25,300 302,000 19,000 400,000 30,000 44,800 6,000 140,000 11,000 100,000 10,600 9,400	1,200 600 1,700 1,100 900 3,150 2,800 1,300 1,700 1,750 1,300 2,200 1,100 7,000 2,300 1,300
	Average of 19 samples, 116,384.	Average of 16 samples, 10,637.		Average of 19 samples, 77,095.	Average of 16 samples, 1,962.
20	10,300 143,000 7,000 5,800 12,000 1,200 5,300 17,400 3,300 3,200 5,400 6,200 20,000 9,700 5,000 6,700 5,200 4,200	3,100 800 5,400 2,900 700 3,800 3,300 4,500 2,700 2,550 2,050 26,100 2,800 2,700 800 10,300	43	4,200 70,000 320,000 64,000 6,600 2,000 9,700 2,600 6,000 6,000 16,000 30,000 64,000 11,400 3,600 4,600 4,000 2,800	1,100 900 2,000 1,700 2,700 5,600 1,700 5,600 2,550 2,050 2,200 1,700 1,600 1,100 1,000 900
	Average of 18 samples, 15,050.	Average of 16 samples, 4,656.		Average of 18 samples, 34,861. Average of 93 samples, 87,391.	Average of 16 samples, 2,150. Average of 80 samples, 4,602.
27	420,000 134,000 91,000 47,000 155,000 93,000 77,000 188,000 118,000 102,000 44,200 406,000 140,000 1,140,000 92,000 34,400 13,300 105,000 153,000	2,300 1,600 3,100 2,400 1,400 4,000 1,900 1,800 1,800 24,000 2,300 1,500 2,800 2,500 2,000 2,300	178 (cream).	12,000 6,000 52,000 15,000 2,400 15,500 17,400 3,200 7,200 24,700 35,700 94,000 300,000 8,000 173,000 20,800	2,100 100 2,200 1,300 4,200 2,250 3,400 3,700 10,000 750 2,000 3,600 2,600 2,400 3,300 4,500
	Average of 19 samples, 186,995.	Average of 16 samples, 3,606.		Average of 16 samples, 49,181.	Average of 16 samples, 3,025.

The average bacterial count of 93 samples of milk taken from the five farms under the ordinary conditions was 87,391 per cubic centimeter, which was reduced to 4,602 after the introduction of the three essential factors. The highest average bacterial count in fresh milk after the introduction of these factors was 10,637 and the lowest 1,962 per cubic centimeter.

It is believed that the results offer proof of the practical value of the three essential factors, namely, sterilized utensils, clean cows with clean udders and teats, and the use of small-top pails, for the production of milk of low bacterial count when fresh, on the average farm. The effect of holding the milk on the farm was not considered in this work.

BACTERIAL COUNTS OF FRESH MILK ON THE AVERAGE FARM.

One of the interesting points noted throughout this work was the fact that very high bacterial counts were not obtained, even under extremely dirty barn conditions, with dirty cows, and unsterilized utensils. As a rule, samples of fresh milk taken directly after milking, when produced under these conditions, contained less than 1,000,000 and usually below 500,000 bacteria per cubic centimeter. It must be remembered that in this work fresh milk which had not been strained or cooled was examined. It is realized, of course, that straining and cooling over unsterilized coolers would increase the bacterial count to some extent. This observation led to the belief that in all probability the bacterial count of fresh milk as produced on the average farm is not so high as has been generally believed.

In order to obtain some information on this point, 249 samples of fresh milk from 12 different farms around Grove City, Pa., were examined during the summer of 1916. The milk was strained but not cooled. The condition of the barns and the methods of handling milk probably represent the average on uninspected farms in the North and North Central part of this country and would score on the average approximately 40 points out of a possible 100, based on the United States Department of Agriculture dairy-farm score card.

The results of the examination of samples of morning's and night's milk are shown in Table 19. The night's samples averaged 115,135, and the morning's samples averaged 180,696 bacteria per cubic centimeter, and the average for all was 135,146.

TABLE 19.—*The bacterial content of 249 samples of fresh milk as produced on 12 farms.*

Farm No.	Bacteria per c. c.	Farm No.	Bacteria per c. c.	Farm No.	Bacteria per c. c.	Farm No.	Bacteria per c. c.	Farm No.	Bacteria per c. c.
1	233,000	14	119,000	20	10,300	27	20,000	43	2,000
	81,000		130,000		143,000		42,000		9,700
	103,000		190,000		7,000		92,000		2,600
	176,000		290,000		5,800		¹ 130,000		6,000
	67,000		90,000		12,000		¹ 242,000		6,000
	220,000		64,000		1,200		¹ 36,000		16,000
	17,300		¹ 250,000		5,300		¹ 4,000		30,000
	139,000		¹ 505,000		17,400		¹ 26,000		64,000
	15,200		¹ 400,000		3,300		¹ 250,000		11,400
	16,900		¹ 660,000		3,200		¹ 16,000		3,600
	28,500		¹ 145,000		5,400		¹ 20,000		4,600
	49,000		¹ 820,000		6,200		¹ 64,000		4,000
	212,000		¹ 21,000		20,000				2,800
	49,000		¹ 168,000		9,700		80,000		
	88,000		¹ 230,000		5,000		109,000	47	13,000
	32,800		¹ 470,000		6,700	29	65,000		42,000
	600,000		¹ 121,000		5,200		8,000		15,000
	12,600		¹ 2,270,000		4,200		16,200		19,000
	71,000		¹ 1,890,000				80,000		2,970,000
	110,000		¹ 230,000	23	240,000		8,500		¹ 16,000
	4,000		¹ 1,020,000		400,000		25,300		¹ 6,000
	10,000	16	29,400		112,000		302,000		¹ 55,000
	13,000		25,000		65,000		19,000		¹ 6,000
	60,000		20,000		170,000		400,000		¹ 32,000
	¹ 26,900		13,000		¹ 145,000		30,000		¹ 33,000
	¹ 222,000		22,000		¹ 490,000		44,800		
	¹ 26,000		14,000		¹ 233,000		6,000	78	49,000
	¹ 27,000		4,000		¹ 300,000		140,000		70,000
	¹ 33,000		14,000		¹ 63,000		11,000		180,000
	¹ 100,000		40,000		¹ 37,000		100,000		35,000
	¹ 54,000		27,000	27	420,000		10,600		75,000
	¹ 36,000		95,000		134,000		9,400		62,000
	¹ 56,000		450,000		91,000		6,600		24,000
5	147,000		24,000		47,000		17,000		45,000
	474,000		¹ 480,000		155,000		50,000		12,000
	92,000		¹ 62,000		93,000		8,000		23,000
	127,000		¹ 41,000		77,000		¹ 54,000		136,000
	173,000		¹ 29,000		188,000		¹ 34,000		85,000
	110,000		¹ 22,000		118,000		¹ 6,000		360,000
	34,000	17	30,000		102,000		¹ 15,000		¹ 50,000
	20,000		21,000		44,200		¹ 14,000		¹ 153,000
	39,700		20,000		406,000		¹ 114,000		¹ 58,000
	26,000		78,000		140,000		¹ 27,000		¹ 29,000
14	219,000		84,000		¹ 140,000		¹ 40,000		¹ 24,000
	445,000		¹ 40,000		92,600		¹ 170,000		¹ 38,000
	237,000		¹ 4,000		34,400				¹ 10,000
	205,000		¹ 11,000		13,300		4,200		¹ 34,000
	204,000		¹ 98,000		105,000	43	70,000		180,000
	69,000		¹ 33,000		153,000		320,000		¹ 77,000
	46,000		¹ 34,000		82,000		64,000		¹ 66,000
					44,000		6,600		¹ 51,000

¹ Morning's milk.

Average of all samples, 249, taken on 12 farms was 135,146 bacteria per cubic centimeter.

Average of 173 samples of night's milk taken on 12 farms was 115,135 bacteria per cubic centimeter.

Average of 76 samples of morning's milk taken on 9 farms was 180,696 bacteria per cubic centimeter.

The samples may be grouped according to the number of bacteria per cubic centimeter, as follows:

	Samples.
1,000,001 or more.....	6
500,001 to 1,000,000.....	4
250,001 to 500,000.....	16
100,001 to 250,000.....	49
50,001 to 100,000.....	44
50,000 or below.....	130
Total.....	249

These figures indicate that the presence of millions of bacteria in milk, which in the past have been considered to a large extent as

evidence of great contamination, is evidently not due in most cases to original contamination. The results show that extremely high counts in milk are in general the result of bacterial growth rather than original contamination.

THE EFFECT OF TEMPERATURE ON THE GROWTH OF BACTERIA IN MILK.

The results shown in the previous discussion of the factors essential for the production of milk of low bacterial count when fresh apply only to fresh milk. The dairyman must remember that when milk of that kind has been produced his responsibility has not ended, for the milk must be kept cold to prevent the growth of bacteria. The three factors discussed prevent to a large degree the contamination of milk during production, as the term is used in this bulletin. In the broad sense of the term "production of milk," the effect of temperature at which the milk is held on the farm must also be considered. It is one of the greatest problems in the handling of milk on the farm, and extensive studies have been made to show the effect of holding milk at different temperatures during varying lengths of time. Samples of milk produced under different conditions were held at 4.4°, 10°, and 15.5° C. (40°, 50°, and 60° F.) and examined when fresh and after each interval of 24 hours for 96 hours, or 4 days. The milk was produced in the experimental barn under three different sets of conditions, as follows:

First. Cows were clean and bedded; the udders washed part of the time and left unwashed part of the time; the small-top pail used; and all utensils were sterilized.

Second. Cows were dirty; the manure was removed twice a week; both open and small-top pails used; and all utensils were sterilized.

Third. Conditions same as second except that the utensils were not sterilized.

Complete detailed results showing the growth of the bacteria in the milk produced under the different conditions mentioned are given. Twenty samples produced under condition 1 were studied; 34 samples under condition 2, and 30 under condition 3.

The bacterial development in milk having a low count, as described under the first condition, is shown in Table 20. The calculated ratio of the bacterial growth in each sample is shown in Table 21. The bacterial development in milk under the second condition mentioned is shown in Table 22 and the ratio of the bacterial development in Table 23. Tables 24 and 25 show similar results for milk produced under the third condition. The summary of the averages of all the samples studied during this work is shown in Table 26. It will be noted that the milk produced under the three conditions when fresh showed somewhat different bacterial counts; that produced under condition 1 averaged 4,295 bacteria per cubic centimeter; under condition 2, 39,082; and under condition 3, 136,533. It will be seen,

therefore, that three different grades of milk, based on their bacterial counts, were considered.

The figures presented in the tables show that with two samples of approximately the same initial bacterial count the increase was not always at exactly the same rate. In some determinations there were occasional counts far above normal at given periods, which can be explained by the fact that there may have been a slight variation in bacterial types, although the initial count was approximately the same. One type may have grown more rapidly at a certain temperature than the types in other samples. It is believed, however, that in this work the variations above the normal were due to inability to control absolutely the temperatures in the holding boxes. In general, however, the variations had little or no effect upon the average counts for the entire series of samples studied.

In Table 26 the average results have been grouped in two different ways; first, to show the growth of bacteria in a series of samples produced under the three conditions and having different initial counts, when held at 4.4°, 10°, and 15.5° C. (40°, 50°, and 60° F.), respectively; second, to show the growth of bacteria in each grade of milk when held at the same temperatures. In the lower part of the table are shown the average ratios of bacterial growth arranged to correspond to the counts in the upper portion. The ratios were obtained by dividing the count, after each successive period of 24 hours, by the initial count.

In the sample held at 4.4° C. (40° F.) there was a relatively small growth of bacteria during the period of 96 hours. A most interesting effect of temperature on the growth of bacteria is shown by the samples of milk produced under the third condition and held at 10° C. (50° F.). It will be seen that when milk with an average count of 4,295 was held for 72 hours, the average count was but little higher than that of milk with an original count of 136,553 per cubic centimeter held 24 hours at the same temperature. A similar condition was found also among samples of low-count milk held 48 hours at 15.5° C. (60° F.), which showed a count of approximately 33,000,000 bacteria, while high-count milk reached approximately 24,000,000 in 24 hours. At the end of 96 hours the bacterial growth reaches a point where the counts are so high as to be approximately the same for all grades of milk.

It is evident that the development of bacteria in different grades of milk at 10° C. (50° F.) has a direct practical bearing. For example, if milk were produced on a farm under conditions¹ which when fresh averaged approximately 4,000 bacteria per cubic centimeter, when held at 10° C. (50° F.) for 48 hours it would contain an average of approximately 127,000. If milk were produced under

¹ Morning's milk,

condition 3, which when fresh averaged approximately 136,000 bacteria per cubic centimeter, when held for 48 hours at 10° C. (50° F.) its average count would be approximately 13,000,000. The difference in count would be of great importance if an attempt were being made to market a milk of low bacterial content.

TABLE 20.—*Growth of bacteria in milk produced under condition 1 when held at 4.4°, 10°, and 15.5° C. (40°, 50°, and 60° F.).*

Sample No.	Temperature.	Fresh.	24 hours.	48 hours.	72 hours.	96 hours.
1.....	4.4° C. (40° F.).	3,500	2,500	3,300	14,400	21,100
2.....		6,900	7,700	7,300	8,900	13,100
3.....		3,400	3,700	3,800	4,100	3,400
4.....		7,400	7,100	6,200	4,100	3,500
5.....		4,700	5,900	5,300	4,200	16,000
6.....		5,300	3,300	2,900	11,600	.....
7.....		7,300	5,300	4,500	.....	8,500
8.....		3,300	4,200	.....	3,400	7,600
9.....		9,400	.....	11,400	11,800	21,000
10.....		3,900	4,100	3,900	5,400	.....
11.....		3,900	7,400	5,300	10,100	18,200
12.....		4,200	3,500	4,700	9,300	22,600
13.....		4,700	4,300	4,800	5,200	6,500
14.....		1,600	2,300	2,500	3,800	23,400
15.....		3,400	3,800	6,900	40,500	109,000
16.....		2,200	2,400	2,300	2,200	.....
17.....		2,900	2,000	3,200	.....	21,000
18.....		1,400	1,700	.....	6,100	18,000
19.....		3,400	.....	1,600	2,500	2,200
20.....		2,100	2,700	2,300	4,100	.....
Average.....		4,295	4,138	4,566	8,427	19,693
1.....	10° C. (50° F.).	3,500	6,400	8,200	4,500,000	34,800,000
2.....		6,900	14,400	55,600	3,760,000	96,000,000
3.....		3,400	5,800	26,000	570,000	13,300,000
4.....		7,400	8,900	35,000	260,000	19,300,000
5.....		4,700	10,800	33,000	8,700,000	43,500,000
6.....		5,300	6,100	510,000	6,400,000	.....
7.....		7,300	5,100	22,000	.....	6,700,000
8.....		3,300	4,700	.....	180,000	.....
9.....		9,400	.....	28,000	90,000	4,100,000
10.....		3,900	5,900	18,500	1,440,000	.....
11.....		3,900	8,100	7,200	5,100,000	95,000,000
12.....		4,200	41,200	900,000	39,000,000	212,000,000
13.....		4,700	20,200	205,000	1,260,000	14,200,000
14.....		1,600	18,200	71,000	1,150,000	20,200,000
15.....		3,400	65,000	280,000	31,000,000	55,000,000
16.....		2,200	5,200	13,600	190,000	.....
17.....		2,900	12,700	42,000	.....	12,200,000
18.....		1,400	6,400	.....	190,000	1,400,000
19.....		3,400	.....	28,000	95,000	3,600,000
20.....		2,100	6,200	16,000	170,000	.....
Average.....		4,295	13,961	127,727	5,725,277	39,490,625
1.....	15.5° C. (60° F.).	3,500	1,250,000	74,000,000	265,000,000	4,240,000,000
2.....		6,900	1,300,000	42,500,000	170,000,000	.....
3.....		3,400	160,000	13,200,000	87,000,000	208,000,000
4.....		7,400	156,000	20,600,000	172,000,000	1,180,000,000
5.....		4,700	10,200,000	31,800,000	1,550,000,000	2,100,000,000
6.....		5,300	1,010,000	28,200,000	242,000,000	.....
7.....		7,300	310,000	18,900,000	.....	149,000,000
8.....		3,300	55,000	.....	74,000,000	106,000,000
9.....		9,400	.....	5,800,000	71,000,000	152,000,000
10.....		3,900	270,000	14,800,000	248,000,000	.....
11.....		3,900	1,220,000	63,000,000	750,000,000	910,000,000
12.....		4,200	1,580,000	85,000,000	1,640,000,000	.....
13.....		4,700	240,000	23,100,000	112,000,000	276,000,000
14.....		1,600	74,000	17,300,000	22,000,000	1,490,000,000
15.....		3,400	10,100,000	97,100,000	152,000,000	2,040,000,000
16.....		2,200	102,000	24,900,000	112,000,000	.....
17.....		2,900	110,000	14,500,000	.....	270,000,000
18.....		1,400	105,000	.....	59,000,000	157,000,000
19.....		3,400	.....	7,900,000	64,000,000	201,000,000
20.....		2,100	330,000	11,600,000	87,000,000	.....
Average.....		4,295	1,587,833	33,011,111	326,500,000	962,785,714

TABLE 21.—Ratio of bacterial growth in milk produced under condition 1 when held at 4.4°, 10°, and 15.5° C. (40°, 50°, and 60° F.).

Sample No.	Temperature.	Fresh.	24 hours.	48 hours.	72 hours.	96 hours.
1.	4.4° C. (40° F.).	1	1.0	0	4.11	6.02
2.		1	1.11	1.05	1.28	1.89
3.		1	1.08	1.09	1.20	1
4.		1	0	0	0	0
5.		1	1.25	1.12	0	3.40
6.		1	0	0	2.18	
7.		1	0	0		1.16
8.		1	1.27		1.03	2.30
9.		1		1.21	1.25	2.23
10.		1	1.05	1	1.38	
11.		1	1.89	1.35	2.58	4.66
12.		1	0	1.11	2.21	5.38
13.		1	0	1.02	1.10	1.38
14.		1	1.43	1.56	2.37	1.46
15.		1	1.11	2.02	11.91	32.05
16.		1	1.09	1.04	1	
17.		1	0	1.10		7.24
18.		1	1.21		4.35	1.28
19.		1		0	0	0
20.		1	1.28	1.09	1.95	
Average.....			1.25	1.21	2.66	5.10
1.	10° C. (50° F.).	1	1.82	2.34	1,285.7	9,942.8
2.		1	2.08	8.05	544.9	13,913
3.		1	1.70	7.64	167.6	3,911.7
4.		1	1.20	4.72	35.1	2,608.1
5.		1	2.29	7.02	1,851	9,255.3
6.		1	1.15	96.20	1,018.8	
7.		1	0	3.01		917.8
8.		1	1.42		54.5	166.6
9.		1		2.97	9.5	436.1
10.		1	1.51	4.74	369.2	
11.		1	2.07	1.84	1,307.6	24,358.9
12.		1	9.80	214.20	9,285.7	50,476.1
13.		1	4.29	43.60	268	3,021.2
14.		1	11.37	44.30	718.7	12,625
15.		1	1.91	82.30	9,117.6	16,176.4
16.		1	2.36	6.18	86.3	
17.		1	4.37	14.40		4,206.8
18.		1	4.57		135.7	1,000
19.		1		8.23	27.9	1,058.8
20.		1	2.95	7.61	80.9	
Average.....			3.34	31.07	1,464.7	9,629.6
1.	15.5° C. (60° F.).	1	357.1	21,142.8	75,714.2	1,211,428.5
2.		1	188.4	6,159.4	24,637.6	
3.		1	47	3,882.3	25,588.2	61,176.4
4.		1	21	2,783.7	23,213.2	159,459.4
5.		1	2,170.2	6,765.9	329,787.2	446,808.5
6.		1	190.5	5,320.7	45,660.9	
7.		1	42.4	2,589		20,410.9
8.		1	16.6		22,424.2	32,121.2
9.		1		617	7,553.1	16,170.2
10.		1	69.2	3,794.8	63,589.7	
11.		1	312.8	16,153.8	192,307.6	233,333.3
12.		1	376.1	20,238	390,476.1	
13.		1	51	4,914.8	23,829.7	58,723.4
14.		1	46.2	10,812.5	13,750	931,250
15.		1	2,970.5	28,558.8	44,705.8	600,000
16.		1	46.3	11,318.1	50,909	
17.		1	37.9	5,000		93,103.4
18.		1	75		42,142.8	112,142.8
19.		1		2,323.5	18,823.5	59,117.6
20.		1	157.1	5,523.8	41,428.5	
Average.....			398.6	8,772.1	79,809.5	288,231.8

¹ Bacterial count less than initial count.

TABLE 22.—*Growth of bacteria in milk produced under condition 2 when held at 4.4°, 10°, and 15.5° C. (40°, 50°, and 60° F.).*

Sample No.	Temperature.	Fresh.	24 hours.	48 hours.	72 hours.	96 hours.
1.....	4.4° C. (40° F.)	10,600	11,600	19,000	.....	508,000
2.....		8,100	14,500	.....	14,800	.....
3.....		13,900	.....	14,100	.....	35,000
4.....		165,000	176,000	.....	254,000	660,000
5.....		240,000	.....	370,000	.....	480,000
6.....		83,000	290,000	.....	1,560,000	3,050,000
7.....		65,000	249,000	300,000	410,000	.....
8.....		121,000	890,000	970,000	.....	.....
9.....		16,500	29,800	20,100	37,000	26,000
10.....		19,600	39,300	35,600	23,000	.....
11.....		69,000	65,000	448,000	.....	15,300,000
12.....		66,000	72,000	.....	98,000	156,000
13.....		53,000	.....	199,000	470,000	620,000
14.....		8,900	11,500	17,700	24,000	29,000
15.....		16,100	13,400	34,000	28,000	.....
16.....		4,100	7,900	8,200	.....	4,100
17.....		65,000	82,000	.....	217,000	1,800,000
18.....		4,300	4,400	5,500	.....	38,000
19.....		5,600	13,700	.....	11,800	.....
20.....		10,800	.....	9,600	.....	32,000
21.....		26,900	29,500	.....	46,000	67,000
22.....		29,800	.....	74,000	77,000	.....
23.....		14,600	111,000	371,000	355,000	115,000
24.....		19,700	79,000	141,000	106,000	.....
25.....		78,000	99,000	176,000	.....	.....
26.....		3,200	2,800	2,900	2,700	2,500
27.....		7,500	14,800	22,300	14,500	.....
28.....		7,200	23,300	26,000	.....	220,000
29.....		17,700	45,000	.....	58,000	.....
30.....		31,000	.....	68,000	37,000	34,000
31.....		6,100	20,400	17,800	17,500	13,200
32.....		10,200	9,800	18,600	19,600	.....
33.....		8,400	10,100	11,200	.....	4,500
34.....		23,000	59,000	.....	49,000	58,000
Average.....		39,082	88,028	121,864	186,245	1,056,922
1.....	10° C. (50° F.)	10,600	68,000	270,000	.....	8,100,000
2.....		8,100	137,000	.....	330,000	.....
3.....		13,900	.....	85,000	.....	4,400,000
4.....		165,000	382,000	.....	1,700,000	6,800,000
5.....		240,000	.....	910,000	1,400,000	2,800,000
6.....		83,000	860,000	3,100,000	5,900,000	24,500,000
7.....		65,000	.....	380,000	880,000	.....
8.....		121,000	960,000	1,190,000	.....	.....
9.....		16,500	83,000	389,000	580,000	20,400,000
10.....		19,600	51,000	76,000	6,060,000	.....
11.....		69,000	321,000	9,800,000	.....	82,000,000
12.....		66,000	181,000	.....	800,000	63,000,000
13.....		53,000	.....	1,100,000	2,400,000	5,200,000
14.....		8,900	42,000	112,000	250,000	8,800,000
15.....		16,100	37,000	530,000	320,000	.....
16.....		4,100	18,500	240,000	.....	2,900,000
17.....		65,000	116,000	.....	9,100,000	26,700,000
18.....		4,300	65,000	252,000	.....	4,700,000
19.....		5,600	53,000	.....	2,970,000	.....
20.....		10,800	.....	81,000	.....	900,000
21.....		26,900	123,000	.....	250,000	1,100,000
22.....		29,800	.....	130,000	350,000	380,000
23.....		14,600	348,000	1,080,000	4,600,000	3,900,000
24.....		19,700	176,000	340,000	810,000	.....
25.....		78,000	172,000	740,000	.....	.....
26.....		3,200	5,500	11,000	120,000	3,600,000
27.....		7,500	43,000	167,000	1,900,000	.....
28.....		7,200	78,000	250,000	.....	29,600,000
29.....		17,700	116,000	.....	570,000	3,900,000
30.....		31,000	.....	210,000	430,000	550,000
31.....		6,100	23,000	11,000	45,000	3,200,000
32.....		10,200	47,000	42,000	120,000	.....
33.....		8,400	12,800	26,000	.....	220,000
34.....		23,000	272,000	.....	420,000	1,300,000
Average.....		39,082	177,437	831,615	1,761,458	13,079,166

TABLE 22.—*Growth of bacteria in milk produced under conditions 2 when held at 4.4°, 10°, and 15.5° C. (40°, 50°, and 60° F.)—Continued.*

Sample No.	Temperature.	Fresh.	24 hours.	48 hours.	72 hours.	96 hours.
1.....	15.5° C. (60° F.)	10,600	1,100,000	35,300,000		142,000,000
2.....		8,100	2,100,000		92,000,000	
3.....		13,900		9,600,000		990,000,000
4.....		165,000	4,900,000		390,000,000	2,610,000,000
5.....		240,000		126,000,000	1,690,000,000	1,820,000,000
6.....		81,000		112,000,000	3,470,000,000	2,320,000,000
7.....		65,000	7,200,000	366,000,000	2,280,000,000	
8.....		121,600	4,400,000	339,000,000		
9.....		16,500	3,080,000	53,200,000	108,000,000	1,370,000,000
10.....		19,600	720,000	33,400,000	670,000,000	
11.....		69,000	8,900,000	203,000,000		
12.....		66,000	14,800,000		270,000,000	980,000,000
13.....		53,000		190,000,000	210,000,000	
14.....		8,900	1,870,000	22,800,000	1,200,000,000	2,070,000,000
15.....		16,100	6,400,000	226,000,000	560,000,000	
16.....		4,100	2,400,000	152,000,000		830,000,000
17.....		65,000	4,500,000		630,000,000	5,500,000,000
18.....		4,300	1,200,000	11,600,000		135,000,000
19.....		5,600	1,700,000		42,000,000	
20.....		10,800		8,200,000		1,280,000,000
21.....		26,600	3,600,000		180,000,000	1,340,000,000
22.....		29,800		12,600,000	190,000,000	970,000,000
23.....		14,600	6,100,000	22,000,000	340,000,000	376,000,000
24.....		19,700	17,700,000	61,000,000	524,000,000	
25.....		78,000	5,200,000	34,600,000		
26.....		3,200	140,000	9,700,000	45,000,000	690,000,000
27.....		7,500	5,300,000	19,300,000	520,000,000	
28.....		7,200	2,150,000	158,000,000		
29.....		17,700	2,100,000		180,000,000	1,210,000,000
30.....		31,000		84,000,000	320,000,000	600,000,000
31.....		6,100	1,190,000	19,500,000	140,000,000	780,000,000
32.....		10,200	3,300,000	164,000,000	490,000,000	
33.....		8,400	3,300,000	177,000,000		340,000,000
34.....		23,000	5,100,000		660,000,000	1,590,000,000
Average.....		39,082	4,461,111	99,120,000	633,375,000	1,355,650,000

TABLE 23.—*Ratio of bacterial growth in milk produced under condition 2 when held at 4.4°, 10°, and 15.5° C. (40°, 50°, and 60° F.).*

Sample No.	Temperature.	Fresh.	24 hours.	48 hours.	72 hours.	96 hours.
1.....	4.4° C. (40° F.)	1	1.1	1.8		47.9
2.....		1	1.7		1.8	
3.....		1		1.1		2.5
4.....		1	1.1		1.5	4
5.....		1		1.5	2.2	2
6.....		1	3.5		18.7	36.7
7.....		1	3.6	4.6	6.3	
8.....		1	7.3	8		
9.....		1	1.8	1.2	2.2	1.6
10.....		1	2	1.8	1.2	
11.....		1	10	6.5		221.7
12.....		1	1.1		1.5	2.4
13.....		1		3.7	8.8	11.7
14.....		1	1.3	1.9	2.7	3.2
15.....		1	0	2.1	1.7	
16.....		1	1.9	2		0
17.....		1	1.3		3.3	27.6
18.....		1	1.1	1.3		8.8
19.....		1	2.4		2.1	
20.....		1		0		2.9
21.....		1	1.1		1.7	2.5
22.....		1		2.5	2.6	
23.....		1	7.6	25.4	24.3	7.8
24.....		1	4	7.1	5.4	
25.....		1	1.3	2.2		
26.....		1	0	0	0	0
27.....		1	1.9	2.9	1.9	
28.....		1	3.2	3.6		30.5
29.....		1	2.5		3.3	
30.....		1		2.2	1.2	1.1
31.....		1	3.3	2.9	2.8	2.2
32.....		1	0	1.8	1.9	
33.....		1	1.2	1.3		0
34.....		1	2.5		2.1	2.5
Average.....			2.4	3.8	4.4	22.1

TABLE 23.—Ratio of bacterial growth in milk produced under condition 2 when held at 4.4°, 10°, and 15.5° C. (40°, 50°, and 60° F.)—Continued.

Sample No.	Temperature.	Fresh.	24 hours.	48 hours.	72 hours.	96 hours.
1.	10° C. (50° F.)	1	6.4	25.4	.....	764.1
2.		1	16.9	.....	40.7	.....
3.		1	.....	6.1	.....	316.5
4.		1	2.3	.....	10.3	41.2
5.		1	.....	3.8	58.3	116.6
6.		1	10.3	37.3	71	295.1
7.		1	.....	5.8	13	.....
8.		1	7.9	9.8	.....	.....
9.		1	5	23.5	35.1	1,236.3
10.		1	2.6	3.8	309.1	.....
11.		1	4.6	142	.....	1,188.4
12.		1	2.7	.....	12.1	954.5
13.		1	.....	20.7	45.2	98.1
14.		1	4.7	12.5	28	988.7
15.		1	2.2	39.1	19.8	.....
16.		1	4.5	58.5	.....	707.3
17.		1	1.7	.....	140	410.7
18.		1	15.1	58.6	.....	1,093.5
19.		1	9.4	.....	530.3	.....
20.		1	.....	7.5	.....	83.3
21.		1	4.5	.....	9.3	40.9
22.		1	.....	4.3	11.7	12.7
23.		1	23.8	73.9	315	267.1
24.		1	8.9	17.2	41.1	.....
25.		1	2.2	9.4	.....	.....
26.		1	1.7	3.4	37.5	1,125
27.		1	5.7	22.2	253.3	.....
28.		1	10.8	34.7	.....	4,111.1
29.		1	6.5	.....	32.2	220.3
30.		1	.....	6.7	13.8	17.7
31.		1	3.7	1.8	7.3	524.5
32.		1	4.6	4.1	11.7	.....
33.		1	1.5	3.1	.....	26.2
34.		1	11.8	.....	18.2	56.5
Average.....			6.7	24.3	86	612.3
1.	15.5° C. (60° F.)	1	103.7	3,330.1	.....	13,396.2
2.		1	259.2	.....	11,358	.....
3.		1	.....	690.6	.....	71,223
4.		1	29.6	.....	2,363.6	15,818.1
5.		1	.....	525	7,041.6	7,583.3
6.		1	.....	1,349.4	41,807.2	27,951.8
7.		1	110.7	5,630.7	35,076.9	.....
8.		1	36.4	2,801.6	.....	.....
9.		1	186.6	3,224.2	6,545.4	83,030.3
10.		1	36.7	1,704	34,183.6	.....
11.		1	128.9	2,942	.....	.....
12.		1	224.2	.....	4,090.9	14,848.4
13.		1	.....	3,584.9	3,962.2	.....
14.		1	210.1	2,561.7	134,831.3	232,584.2
15.		1	397.5	14,037.2	34,782.6	.....
16.		1	585.3	37,073.1	.....	202,439
17.		1	69.2	.....	9,692.3	84,615.3
18.		1	279	2,697.6	.....	31,395.3
19.		1	303.5	.....	7,500	.....
20.		1	.....	759.2	.....	118,518.5
21.		1	133.8	.....	6,691.4	49,814.1
22.		1	.....	422.8	6,375.8	32,550.3
23.		1	417.8	1,506.8	23,287.6	25,753.4
24.		1	898.4	3,096.4	26,598.9	.....
25.		1	66.6	443.5	.....	.....
26.		1	43.7	3,031.2	14,062.5	215,625
27.		1	706.6	2,573.3	69,333.3	.....
28.		1	298.6	21,944.4	.....	.....
29.		1	118.6	.....	10,196.4	68,361.5
30.		1	.....	2,709.6	10,322.5	19,354.8
31.		1	195	3,196.7	22,950.8	127,868.8
32.		1	323.5	16,078.4	48,039.2	.....
33.		1	392.8	21,071.4	.....	40,476.2
34.		1	221.7	.....	28,695.6	69,130.4
Average.....			351	6,114.8	21,990.1	73,920.8

¹ Bacterial count less than initial count.

TABLE 24.—*Growth of bacteria in milk produced under condition 3 when held at 4.4°, 10°, and 15.5° C. (40°, 50° and 60° F.).*

Sample No.	Temperature.	Fresh.	24 hours.	48 hours.	72 hours.	96 hours.
1.....	4.4° C. (40° F.)	149,000	262,000	354,000	386,000	620,000
2.....		9,200	8,200	15,600	63,000	9,500
3.....		22,500	39,000	41,000	60,000	.....
4.....		6,300	6,200	24,000	.....	135,000
5.....		6,800	12,200	.....	13,600	19,000
6.....		8,200	127,000	165,000	620,000	970,000
7.....		115,000	356,000	790,000	1,020,000	.....
8.....		207,000	290,000	252,000	.....	.....
9.....		216,000	1,440,000	2,700,000	3,550,000	3,840,000
10.....		202,000	600,000	720,000	910,000	2,700,000
11.....		332,000	278,000	266,000	407,000	.....
12.....		215,000	224,000	256,000	.....	250,000
13.....		209,000	207,000	.....	.....	.....
14.....		176,000	.....	.....	.....	260,000
15.....		256,000	.....	208,000	480,000	460,000
16.....		55,000	52,000	82,000	51,000	106,000
17.....		4,100	2,500	32,000	24,000	5,200
18.....		18,100	37,000	26,000	41,000	.....
19.....		11,400	15,700	38,000	.....	53,000
20.....		12,400	36,000	.....	35,000	68,000
21.....		193,000	313,000	295,000	540,000	596,000
22.....		169,000	243,000	510,000	530,000	.....
23.....		210,000	186,000	300,000	.....	.....
24.....		159,000	650,000	3,900,000	4,200,000	4,800,000
25.....		230,000	970,000	1,450,000	1,720,000	1,560,000
26.....		265,000	254,000	246,000	244,000	.....
27.....		168,000	158,000	162,000	.....	195,000
28.....		157,000	106,000	.....	.....	.....
29.....		186,000	.....	.....	.....	240,000
30.....		128,000	.....	98,000	86,000	170,000
Average.....		136,533	281,646	538,775	749,030	852,835
1.....	10° C. (50° F.)	149,000	380,000	1,770,000	7,900,000	48,000,000
2.....		9,200	37,000	510,000	126,000	3,600,000
3.....		22,500	107,000	2,080,000	34,800,000	.....
4.....		6,300	38,000	490,000	.....	8,600,000
5.....		6,800	91,000	.....	11,700,000	39,400,000
6.....		8,200	1,540,000	9,600,000	31,200,000	78,000,000
7.....		115,000	3,180,000	29,600,000	45,000,000	.....
8.....		207,000	1,560,000	16,800,000	.....	.....
9.....		216,000	2,400,000	53,000,000	65,000,000	96,000,000
10.....		202,000	1,490,000	35,600,000	31,000,000	33,900,000
11.....		332,000	4,200,000	14,300,000	26,300,000	.....
12.....		215,000	930,000	4,400,000	.....	34,200,000
13.....		209,000	840,000	.....	20,100,000	32,200,000
14.....		176,000	.....	9,500,000	24,200,000	36,500,000
15.....		256,000	2,040,000	27,500,000	20,100,000	15,600,000
16.....		55,000	47,000	260,000	220,000	18,400,000
17.....		4,100	4,300	35,000	55,000	560,000
18.....		18,100	43,000	490,000	8,900,000	.....
19.....		11,400	52,000	2,080,000	.....	58,000,000
20.....		12,400	394,000	.....	19,300,000	53,000,000
21.....		193,000	1,230,000	13,900,000	45,000,000	76,000,000
22.....		169,000	620,000	27,000,000	28,800,000	.....
23.....		210,000	560,000	5,700,000	.....	.....
24.....		159,000	2,700,000	42,000,000	68,000,000	110,000,000
25.....		230,000	2,180,000	24,700,000	33,600,000	34,900,000
26.....		265,000	1,210,000	9,100,000	25,200,000	.....
27.....		168,000	560,000	2,770,000	.....	41,300,000
28.....		157,000	240,000	.....	18,800,000	38,700,000
29.....		186,000	.....	4,630,000	26,700,000	23,400,000
30.....		128,000	1,060,000	17,400,000	22,700,000	26,300,000
Average.....		136,533	1,170,546	13,662,115	25,687,541	41,207,272

TABLE 24.—*Growth of bacteria in milk produced under condition 3 when held at 4.4°, 10°, and 15.5° C. (40°, 50°, and 60° F.)—Continued.*

Sample No.	Temperature.	Fresh.	24 hours.	48 hours.	72 hours.	96 hours.
1.....	15.5° C. (60° F.).	149,000	17,800,000	410,000,000	2,430,000,000	.....
2.....		9,200	2,900,000	218,000,000	160,000,000	.....
3.....		22,500	76,000,000	1,060,000,000	1,540,000,000	.....
4.....		6,300	4,700,000	255,000,000	.....	10,400,000,000
5.....		6,800	10,300,000	.....	1,110,000,000	1,640,000,000
6.....		8,200	32,300,000	125,000,000	910,000,000	2,230,000,000
7.....		115,000	22,600,000	198,000,000	1,650,000,000	.....
8.....		207,000	16,200,000	145,000,000	.....	.....
9.....		216,000	46,000,000	165,000,000	1,060,000,000	1,590,000,000
10.....		202,000	11,300,000	128,000,000	190,000,000	1,430,000,000
11.....		332,000	19,400,000	147,000,000	210,000,000	.....
12.....		215,000	9,700,000	126,000,000	.....	1,260,000,000
13.....		209,000	10,200,000	.....	1,160,000,000	8,300,000,000
14.....		176,000	.....	460,000,000	1,720,000,000	4,400,000,000
15.....		256,000	67,000,000	4,200,000,000	6,900,000,000	9,100,000,000
16.....		55,000	1,600,000	1,440,000,000	1,280,000,000	.....
17.....		4,100	510,000	1,050,000,000	3,000,000,000	.....
18.....		18,100	11,600,000	580,000,000	8,400,000,000	.....
19.....		11,400	88,000,000	1,800,000,000	.....	2,190,000,000
20.....		12,400	3,500,000	.....	4,400,000,000	1,750,000,000
21.....		193,000	72,000,000	411,000,000	4,900,000,000	5,400,000,000
22.....		169,000	11,900,000	373,000,000	3,140,000,000	.....
23.....		210,000	11,550,000	310,000,000	.....	.....
24.....		159,000	21,600,000	344,000,000	790,000,000	12,500,000,000
25.....		230,000	28,400,000	362,000,000	730,000,000	21,600,000,000
26.....		265,000	24,400,000	213,000,000	340,000,000	.....
27.....		168,000	7,100,000	87,000,000	.....	3,900,000,000
28.....		157,000	8,300,000	.....	1,970,000,000	4,600,000,000
29.....		186,000	.....	730,000,000	8,400,000,000	2,410,000,000
30.....		128,000	52,000,000	2,270,000,000	1,380,000,000	1,540,000,000
Average.....	.....	139,533	24,673,571	639,884,615	2,407,083,333	5,346,666,666

TABLE 25.—*Ratio of bacterial growth in milk produced under condition 3 when held at 4.4°, 10°, and 15.5° C., 40°, 50°, and 60° F.*

Sample No.	Temperature.	Fresh.	24 hours.	48 hours.	72 hours.	96 hours.
1.....	4.4° C. (40° F.)	1	1.75	2.37	2.59	4.16
2.....		1	1.0	1.09	6.84	1.03
3.....		1	1.73	1.82	2.66	.....
4.....		1	0	3.80	.....	21.40
5.....		1	1.79	.....	2	2.79
6.....		1	1.54	2.01	75.60	118.20
7.....		1	3.09	6.86	8.86	.....
8.....		1	1.40	1.21	.....	.....
9.....		1	6.66	12.50	16.40	17.70
10.....		1	2.97	3.56	4.50	13.30
11.....		1	0	0	1.22	.....
12.....		1	1.04	1.19	.....	1.16
13.....		1	0	.....	.....	.....
14.....		1	.....	.....	.....	1.47
15.....		1	.....	0	1.87	1.79
16.....		1	0	1.49	0	1.92
17.....		1	0	7.80	5.85	1.26
18.....		1	2.04	1.43	2.26	.....
19.....		1	1.37	3.33	.....	4.64
20.....		1	2.90	.....	2.82	5.48
21.....		1	1.62	1.52	2.79	3.08
22.....		1	1.43	3.01	3.13	.....
23.....		1	0	1.42	.....	.....
24.....		1	4.08	21.50	26.40	30.10
25.....		1	4.21	6.30	7.47	6.78
26.....		1	0	0	0	.....
27.....		1	0	0	.....	1.16
28.....		1	0	.....	.....	.....
29.....		1	.....	.....	.....	1.09
30.....		1	.....	0	0	1.32
Average.....	.....	.....	2.47	4.62	10.19	11.99

¹ Bacterial count less than initial count.

TABLE 25.—*Ratio of bacterial growth in milk produced under condition 3 when held at 4.4°, 10°, and 15.5° C. (40°, 50°, and 60° F.)—Continued.*

Sample No.	Temperature.	Fresh.	24 hours.	48 hours.	72 hours.	96 hours.
1.	10° C. (50° F.)	1	2.5	11.8	53.0	322.1
2.		1	4	55.4	13.6	391.3
3.		1	4.7	92.4	1,546.6	.....
4.		1	6	77.7	.....	1,365
5.		1	13.3	.....	1,720.5	5,794.1
6.		1	187.8	1,170.7	3,804.8	9,512.1
7.		1	27.6	257.6	391.3	.....
8.		1	7.5	81.1	.....	444.4
9.		1	11.1	245.3	300.9	167.8
10.		1	7.3	176.2	153.4	.....
11.		1	12.6	43	79.2	.....
12.		1	4.3	20.4	.....	159
13.		1	4	.....	96.1	154
14.		1	.....	53.9	137.5	207.3
15.		1	7.9	107.4	78.5	60.9
16.		1	0	4.7	4	334.5
17.		1	1.1	0	13.4	136.5
18.		1	2.3	27	491.7	.....
19.		1	4.5	182.4	.....	5,087.7
20.		1	31.7	.....	1,556.4	4,274.1
21.		1	6.3	72	233.1	393.7
22.		1	3.6	159.7	170.4	.....
23.		1	2.6	27.1	.....	.....
24.		1	16.9	264.1	427.6	691.8
25.		1	9.4	107.3	146	151.7
26.		1	4.5	34.3	95	.....
27.		1	3.3	16.4	.....	245.8
28.		1	1.5	.....	119.7	246.4
29.		1	.....	24.8	143.5	125.8
30.		1	8.2	135.9	177.3	205.4
Average.....			14.6	137.9	498.1	1,385.1
1.	15.5° C. (60° F.)	1	119.4	2,751.6	16,308.7	.....
2.		1	315.2	23,695.6	17,391.3	.....
3.		1	3,377.7	47,111.1	68,444.4	.....
4.		1	746	40,476.1	.....	1,650,793.6
5.		1	1,514.7	.....	163,235.2	241,176.4
6.		1	3,939	15,243.9	110,975.6	271,951.2
7.		1	196.5	1,721.7	14,347.8	.....
8.		1	78.2	700.4	.....	5,860.4
9.		1	212.9	763.8	4,907.4	7,361.1
10.		1	55.9	633.6	940.5	7,079.2
11.		1	58.5	442.7	632.5	.....
12.		1	45.1	586	.....	.....
13.		1	48.8	.....	5,550.2	39,712.9
14.		1	.....	2,613.6	9,772.7	25,000
15.		1	261.7	16,406.2	26,953.1	35,546.8
16.		1	29	26,181.8	23,272.7	.....
17.		1	124.3	256,097.5	731,707.3	.....
18.		1	640.8	32,044.1	464,088.3	.....
19.		1	7,719.2	157,894.7	.....	192,105.2
20.		1	443.5	.....	354,838.7	141,129
21.		1	373	2,129.5	25,388.6	27,979.2
22.		1	70.4	2,207.1	18,520.7	.....
23.		1	55	1,476.1	.....	.....
24.		1	135.8	2,163.5	4,968.5	78,616.3
25.		1	123.4	1,573.9	3,173.9	93,913
26.		1	92	916.9	1,283	.....
27.		1	42.2	517.8	.....	23,214.2
28.		1	52.8	.....	12,547.7	29,299.3
29.		1	.....	3,924.7	45,161.2	12,956.9
30.		1	406.2	17,734.3	10,781.2	12,031.2
Average.....			759.9	25,308	61,527.2	160,873.6

TABLE 26.—*Summary of results shown in Tables 20 to 25 inclusive.*
AVERAGE NUMBER OF BACTERIA.

Temperature.	Condition.	Fresh.	24 hours.	48 hours.	72 hours.	96 hours.
SECTION 1.						
40° F.	1	4,295	4,138	4,566	8,427	19,693
	2	39,082	88,028	121,864	186,245	1,056,922
	3	136,533	281,646	538,775	749,030	852,835
50° F.	1	4,295	13,961	127,727	5,725,277	39,490,625
	2	39,082	177,437	831,615	1,761,458	13,079,166
	3	136,533	1,170,546	13,662,115	25,687,541	41,207,272
60° F.	1	4,295	1,587,333	33,011,111	326,500,000	962,785,714
	2	39,082	4,461,111	99,120,000	633,375,000	1,355,650,000
	3	136,533	24,673,571	639,884,615	2,407,083,333	5,346,666,666
SECTION 2.						
40° F.	1	4,295	4,138	4,566	8,247	19,693
50° F.		4,295	13,961	127,727	5,725,277	39,490,625
60° F.		4,295	1,587,333	33,011,111	326,500,000	962,785,714
40° F.	2	39,082	88,028	121,864	186,245	1,056,922
50° F.		39,082	177,437	831,615	1,731,875	13,097,166
60° F.		39,082	4,461,111	99,120,000	633,375,000	1,355,650,000
40° F.	3	136,533	281,646	538,775	749,030	852,835
50° F.		136,533	1,170,546	13,662,115	25,687,541	41,207,272
60° F.		136,533	24,673,571	639,884,615	2,407,083,333	5,346,666,666

RATIO OF GROWTH.

40° F.	1	1	1.25	1.21	2.66	5.10
	2	1	2.40	3.80	4.40	22.10
	3	1	2.47	4.62	10.19	11.99
50° F.	1	1	3.34	31.07	1,464.70	9,629.60
	2	1	6.70	24.30	86.00	612.30
	3	1	14.68	137.94	498.06	1,385.06
60° F.	1	1	398.60	8,772.10	79,809.50	288,231.80
	2	1	351.00	6,114.80	24,990.10	73,920.80
	3	1	759.90	25,308.00	61,527.20	160,873.60
40° F.	1	1	1.25	1.21	2.66	5.10
50° F.		1	3.34	31.07	1,464.70	9,629.60
60° F.		1	398.60	8,772.10	79,809.50	288,231.80
40° F.	2	1	2.40	3.80	4.40	22.10
50° F.		1	6.70	24.30	86.00	612.30
60° F.		1	351.00	6,114.80	24,990.10	73,920.80
40° F.	3	1	2.47	4.62	10.19	11.99
50° F.		1	14.68	137.94	498.06	1,385.06
60° F.		1	759.90	25,308.00	61,527.20	160,873.60

The effect of low temperature on the bacterial growth in any one of the grades of milk demands special attention. From section 2 of Table 26, it is evident that even if milk when fresh shows a low bacterial count the number of bacteria will be high if it is held at a high temperature. For example, milk with an average count of approximately 4,000 when held 24 hours at 4.4° C. (40° F.) showed approximately the same count. At 10° C. (50° F.) the count was about 13,000, while at 15.5° C. (60° F.) the average was about 1,500,000. The results show in every case the great value of holding milk at 10° C. (50° F.) rather than 15.5° C. (60° F.)

It is realized that night's milk is generally held on the farm for periods of from 12 to 15 hours before delivery; it is, therefore, important to know what bacterial increase will occur in milk held about that period of time. In order to obtain data on the subject, samples of milk produced under clean conditions in sterilized utensils and also

samples of milk produced under dirty conditions were held at 15.5° C. (60° F.) and 21.1° C. (70° F.) and examined when fresh, and after 12, 24, and 48 hours.

From Table 27 it will be seen that 16 samples of milk produced under clean conditions in sterilized utensils when fresh averaged 3,243 bacteria per cubic centimeter. After 12 hours at 15.5° C. (60° F.) the average count was 4,056 and at 21.1° C. (70° F.) 19,312 bacteria per cubic centimeter. This shows an advantage of holding at the lower temperature which is more valuable when the milk is held for 24 hours, as the average count was then 123,562 when held at 15.5° C. (60° F.) and 10,006,875 when held at 21.1° C. (70° F.). After 48 hours the average count at both temperatures was high, but the milk held at 15.5° C. (60° F.) was much lower.

The samples of milk produced under dirty conditions in unsterilized utensils ranged from 10,900 to 2,210,000 when fresh and averaged 707,761 bacteria per cubic centimeter. This high initial average count increased to 3,376,961 after 12 hours at 15.5° C. (60° F.) and to 6,608,846 after 12 hours at 21.1° C. (70° F.). The counts were, of course, very high at later periods at both temperatures.

TABLE 27.—*Growth of bacteria in milk when held at 15.5° C. (60° F.) and 21.1° C. (70° F.).*

MILK PRODUCED UNDER CLEAN CONDITIONS IN STERILIZED UTENSILS.

Sample No.	Fresh.	Held at 15.5° C. (60° F.) for—			Held at 21.1° C. (70° F.) for—		
		12 hours.	24 hours.	48 hours.	12 hours.	24 hours.	48 hours.
1.....	1,800	2,300	48,000	13,200,000	8,100	4,100,000	1,290,000,000
2.....	1,900	2,000	56,000	16,500,000	23,100	26,200,000	860,000,000
3.....	1,700	1,100	55,000	38,000,000	13,600	23,700,000	2,410,000,000
4.....	3,100	1,800	54,000	.....	29,100	12,400,000	.....
5.....	11,200	7,300	83,000	41,000,000	14,700	4,700,000	1,340,000,000
6.....	7,900	8,700	51,000	57,000,000	37,000	8,200,000	1,810,000,000
7.....	1,800	2,100	78,000	12,600,000	2,300	510,000	81,000,000
8.....	700	1,700	28,000	4,500,000	6,800	1,880,000	82,000,000
9.....	5,600	1,900	23,000	20,100,000	25,200	5,400,000	2,980,000,000
10.....	1,100	3,100	74,000	42,000,000	19,500	30,600,000	128,000,000
11.....	3,400	5,100	38,000	14,100,000	13,200	10,200,000	960,000,000
12.....	1,400	18,300	810,000	.....	58,000	5,700,000	.....
13.....	3,100	2,200	60,000	18,100,000	4,100	4,100,000	1,350,000,000
14.....	1,200	2,000	261,000	46,000,000	32,500	4,920,000	6,400,000,000
15.....	3,800	3,000	112,000	16,600,000	5,800	6,000,000	6,460,000,000
16.....	2,200	2,300	146,000	.....	16,000	11,500,000	.....
Average.	3,243	4,056	123,562	26,176,923	19,312	10,006,875	2,014,692,307

MILK PRODUCED UNDER DIRTY CONDITIONS IN UNSTERILIZED UTENSILS.

1.....	10,900	15,500	182,000	.....	58,000	49,000,000	.....
2.....	1,520,000	8,600,000	148,000,000	169,000,000	12,800,000	460,000,000	1,780,000,000
3.....	1,880,000	8,700,000	154,000,000	840,000,000	17,600,000	960,000,000	7,500,000,000
4.....	1,030,000	5,400,000	22,900,000	1,180,000,000	8,200,000	630,000,000	460,000,000
5.....	2,210,000	11,700,000	81,000,000	28,000,000	13,700,000	149,000,000	620,000,000
6.....	1,810,000	1,930,000	68,000,000	164,000,000	6,100,000	75,000,000	540,000,000
7.....	330,000	4,200,000	10,300,000	113,000,000	10,200,000	37,000,000	1,860,000,000
8.....	159,000	1,210,000	22,600,000	110,000,000	2,830,000	.....	350,000,000
9.....	96,000	1,310,000	29,400,000	.....	10,400,000	114,000,000	.....
10.....	37,000	560,000	43,800,000	212,000,000	2,360,000	26,000,000	1,840,000,000
11.....	18,000	180,000	47,200,000	100,000,000	1,370,000	96,000,000	1,500,000,000
12.....	12,000	24,000	1,480,000	45,000,000	99,000	32,000,000	2,080,000,000
13.....	28,000	71,000	2,300,000	.....	198,000	35,000,000	.....
Average.	707,761	3,376,961	48,550,923	296,100,000	6,608,846	221,916,666	1,853,000,000

The ratio of growth of bacteria in Table 28 shows an interesting point. The ratios were determined as previously explained in this publication (p. 46). It will be noted that there was a higher ratio of growth in milk produced under dirty conditions in unsterilized utensils than in samples of milk produced under clean conditions in sterilized utensils. This seemed to be true when milk was held at 15.5° C. (60° F.) for 12 and 24 hours. At 21.1° C. (70° F.) the statement holds true only for the first 12 hours. From that and other observations it seems evident that the bacteria which are introduced from unsterilized utensils grow faster at temperatures near 15.5° C. (60° F.) than those in a low-count milk produced in sterilized utensils.

The results obtained by holding milk at 15.5° C. (60° F.) and 21.1° C. (70° F.) for various periods of time, show the advantage of the lower temperature and farther give data on the bacterial increase which will take place at those temperatures when both low and high count milk are held for varying periods of time.

The effect of temperature on the growth of bacteria in milk during storage and transportation is a matter of very great importance. It is evident from the previous results that if a low-count milk is desired it must be cooled and held at 10° C. (50° F.) or lower on the farm, unless it is delivered immediately after each milking. Therefore, for the production, in a broad sense of the term, of milk of low bacterial content a fourth factor, proper refrigeration, must be added to the three factors previously discussed.

TABLE 28.—*Ratio of growth of bacteria in milk when held at 15.5° C. (60° F.) and 21.1° C. (70° F.).*

MILK PRODUCED UNDER CLEAN CONDITIONS IN STERILIZED UTENSILS.

Sample No.	Fresh.	Held at 15.5° C. (60° F.) for—			Held at 21.1° C. (70° F.) for—		
		12 hours.	24 hours.	48 hours.	12 hours.	24 hours.	48 hours.
1.....	1	1.27	26.6	7,333.3	4.5	2,277.7	716,666.6
2.....	1	1.05	29.4	8,684.2	12.1	13,789.4	452,631.5
3.....	1	0	32.3	22,352.9	8	13,941.1	1,417,647
4.....	1	0	17.4	.....	9.3	4,000	.....
5.....	1	0	7.4	36,607.1	1.3	419.6	119,642.8
6.....	1	1.07	6.4	7,215.1	4.6	1,037.9	229,113.9
7.....	1	1.16	43.3	7,166.6	1.2	283.3	45,000
8.....	1	2.43	40	6,428.5	9.7	2,685.7	115,714.2
9.....	1	0	4.1	3,589.2	4.5	964.2	532,142.8
10.....	1	2.81	67.2	38,181.8	17.7	27,818.1	116,363.6
11.....	1	1.50	11.1	4,147	3.8	3,000	282,352.9
12.....	1	13.07	578.5	.....	41.4	4,071.4	.....
13.....	1	0	19.3	5,838.7	1.3	1,322.5	448,387
14.....	1	1.66	217.5	38,333.3	27.1	4,100	533,333.3
15.....	1	0	29.4	4,368.4	1.5	1,578.9	1,700,000
16.....	1	1.04	66.3	.....	7.2	5,227.2	.....
Average.....	.....	1.69	74.76	14,634.3	9.7	5,407.3	885,307.3

TABLE 28.—*Ratio of growth of bacteria in milk when held at 15.5° C. (60° F.) and 21.1° C. (70° F.)—Continued.*

MILK PRODUCED UNDER DIRTY CONDITIONS IN UNSTERILIZED UTENSILS.

1.....	1	1.4	16.6	.....	5.3	4,495.4	.....
2.....	1	5.6	97.3	1,111.8	8.4	302.6	11,710.5
3.....	1	4.5	81.9	446.8	9.3	510.6	3,989.3
4.....	1	4.9	21	1,082.5	7.5	577.9	422
5.....	1	5.3	36.6	12.6	6.2	67.4	280.5
6.....	1	1	37.5	90.6	3.4	41.4	298.3
7.....	1	1.2	31.2	342.4	30.9	112.1	5,636.3
8.....	1	7.6	142.1	691.8	17.7	.....	2,201.2
9.....	1	13.6	136.4	.....	108.3	1,187.5	.....
10.....	1	15.1	1,183.7	5,729.7	63.7	702.7	49,729.7
11.....	1	10	2,622.2	5,555.5	76.1	5,333.3	83,333.3
12.....	1	2	123.3	3,750	8.2	2,666.6	173,333.3
13.....	1	2.5	82.1	.....	7.1	1,250	.....
Average.....	.....	5.7	354.7	1,881.3	27	1,437.3	33,093.4

SUMMARY.

1. Milk of low bacterial content and practically free from visible dirt, when fresh, was produced in an experimental barn under conditions similar to those on the average low-grade farm.

2. Three simple factors were necessary for the production of milk with a low bacterial content, namely, sterilized utensils, clean cows with clean udders and teats, and the small-top pail. A fourth factor, holding the milk at a temperature near 10° C. (50° F.) or lower, is necessary in order to keep the bacterial content low.

3. The average count of 65 samples of fresh milk produced by the aid of the three factors, except that the udders and teats were not washed, was 4,524 bacteria per cubic centimeter. The average count of milk directly from the udder was 757 bacteria per cubic centimeter; the difference of 3,767 therefore represents the number introduced through external contamination. During the same period when the udder and teats of the cows were washed, the average of the 65 samples was 2,154 bacteria per cubic centimeter, and as the average udder count was 739, the difference, 1,415 bacteria, represented those added through external contamination.

Washing the udder and teats of the cows not only caused a decrease in the bacterial content of the milk but also more nearly uniform counts.

A study of the bacterial groups in the low-count milk showed that they correspond closely to those in the milk drawn directly from the udder.

4. A practical demonstration of the value of the three essential factors was made on six farms. The results indicate that it is possible for the average farmer with inexpensive equipment to produce milk of low bacterial content with little extra work.

5. The results indicate that in general the greatest contamination of milk comes from the use of unsterilized utensils. The simple steam

sterilizer described in Farmers' Bulletin 748¹ was used very successfully for the sterilization of utensils on the farms.

6. Small-top pails were found to lessen the quantity of manure which may gain entrance into milk and to assist in lowering the bacterial count.

7. The sediment test was found to bear a somewhat close relation to the number of bacteria in fresh, unstrained milk handled in sterilized utensils.

8. From an examination of a large number of samples of fresh milk produced under varying conditions in an experimental barn and of samples from a number of farms, it is believed that as a general rule the bacterial content is relatively low. It would seem that when the count is in the millions it is the result of bacterial growth in the milk while being held.

9. To show the growth of bacteria in milk held at various temperatures for varying periods, a large number of samples were held at 4.4°, 10°, 15.5°, and 21.1° C. (40°, 50°, 60°, and 70° F.). It is absolutely necessary, if milk is held on the farm, to keep it near 10° C. (50° F.) or lower, in order to restrain bacterial growth, if the dairyman wishes to market milk of low bacterial content.

CONCLUSIONS.

The results of the experiments indicate that it is possible for the average dairyman on the average farm, without expensive barns and equipment, to produce milk (practically free from visible dirt) which when fresh has a low bacterial count. By the use of the three simple factors, namely, sterilized utensils, clean cows with clean udders and teats, and the small-top pail, it should be possible on the average farm to produce milk which corresponds closely to milk as it leaves the udder of the cow. A fourth factor of holding milk at as near 10° C. (50° F.) as possible is also absolutely necessary.

To emphasize the value of the three simple factors, figure 23 shows the average bacterial counts of milk produced under the various conditions described in this bulletin. The results will not be discussed in detail, but in a general way the figure gives a picture of the results of the experiments in the order in which they were conducted. The experiments were begun with dirty conditions and unsterilized utensils, and milk of high bacterial count was obtained. Next the factor of sterilized utensils was introduced, followed by the additional factor of clean udder and teats. A combination of the factors and the use of a small-top pail permitted the production of a low-count milk, which closely corresponded to that drawn directly from the udder. In order to check the value of the essential factors, they were again eliminated until a high-count milk was produced, then reintroduced until a low-count milk was again obtained.

¹ Farmers' Bulletin 748 will be sent free to any one on application to the department.

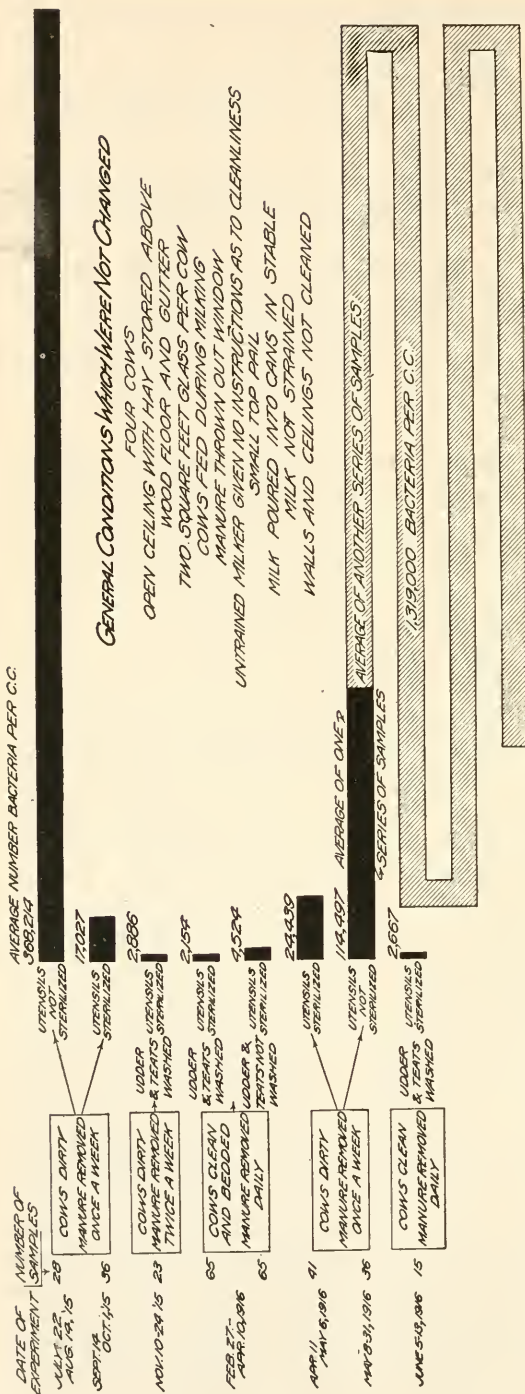


Fig. 23.—Summary of results showing the average bacterial content of milk produced under the various conditions described in this paper.

The value of these factors was thoroughly determined by experiments conducted in an experimental barn and further demonstrated by their successful practical application on several farms.

In connection with the production of milk of low bacterial content and which is practically free from visible dirt, it seems evident from the results that undue emphasis has been given to factors and methods of minor importance, while those which directly affect the bacterial content have not been sufficiently emphasized.

It must again be pointed out that only one phase of the production of a sanitary milk has been considered in this paper. No attempt has been made to study the factors which are most directly concerned with preventing the infection of milk by pathogenic organisms. The factors affecting the health of the cattle have not

been studied, nor has the influence of general conditions of cleanliness surrounding the production of milk been given consideration.

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UNITED STATES DEPARTMENT OF AGRICULTURE
BULLETIN No. 643

Contribution from the Bureau of Entomology
L. O. HOWARD, Chief

Washington, D. C. March 8, 1918

THE MELON FLY

By

E. A. BACK, Entomologist
and C. E. PEMBERTON, Assistant Entomologist
Mediterranean and Other Fruit Fly Investigations

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THE MELON FLY is a truck-crop pest that in the course of international commerce has been spread from its native home in the Indo-Malayan region to the Hawaiian Islands, and has become so thoroughly established that it can not be eradicated. Owing to its destructive work, such fruits as muskmelons, watermelons, pumpkins, squashes, cucumbers, vegetable marrows, and tomatoes can not be grown to-day in many parts of the Hawaiian Islands unless the plants are screened. Cantaloupes and watermelons, instead of being common and cheap delicacies, as in former years, are now a luxury even for the wealthy; and cantaloupes, formerly grown in quantities about Honolulu, are now imported from California. Owing to the danger of introducing the melon fly into countries where it does not now exist, quarantines prohibit the export of Hawaiian-grown eggplant, bell peppers, and tomatoes, thus shutting off an income formerly enjoyed by the small farmer. In short, it is not possible to exaggerate the seriousness of this insect under Hawaiian coastal conditions.

The problem, however, is not entirely a local one to be fought out by the people of Hawaii. Should the melon fly once break through the Federal quarantine barriers and become established on the mainland of the United States, it will exact a large annual toll of the truck crops of the South. It is important, therefore, that truck growers learn something about this pest, so difficult of control, in order that they may become actively interested in keeping it out.



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THE MELON FLY is a serious pest that never should have gained access to the Hawaiian Islands. Its establishment in Hawaii came naturally enough, as in the case of many of our worst insect enemies, along with the development of unrestricted modern commerce, and owing to the lack, in earlier days, of a knowledge of pests in other lands likely to be introduced into ours, or of any quickened public opinion which, at last thoroughly alive to the great financial losses that may be averted, is to-day heartily supporting Federal quarantines directed against just such pests as the melon fly.

The melon fly is now established thoroughly throughout the coastal regions of the Hawaiian Islands and never will be eradicated. It attacks many vegetables that otherwise could be grown readily by the poorer people, who are least able to purchase them. Melons, pumpkins, squashes, cucumbers, and tomatoes, and some

¹ *Bactrocera cucurbitae* Coq.; order Diptera, family Trypetidae.

For a more extended account of the melon fly see Back, E. A., and Pemberton, C. E. The melon fly in Hawaii. U. S. Dept. Agr. Bul. 491. 64 p., 24 pl., 10 fig. 1917. This may be obtained from the Superintendent of Documents, Government Printing Office, Washington, D. C., for 25 cents.

NOTE.—The manuscript of this paper was prepared for publication as a Farmers' Bulletin, but owing to the fact that it deals with an insect which has not yet been introduced into the continental United States it was considered more appropriate to issue it in the series of Department Bulletins.

other vegetables to-day can not be grown in many parts of the islands except with great effort; they must be imported from across the sea, as a result of melon-fly attack.

The melon fly is capable of living and causing damage throughout the warmer portions of the mainland United States. As it is



FIG. 1.—Tip of watermelon vine, showing adult melon fly laying eggs in ovary of a flower still in bud, an unaffected male bloom, and withered and drooping growing tip of vine. A female melon fly has deposited eggs in the vine at base of leafstalk, and the young larvæ hatching have nearly severed the vine at this point. (Authors' illustration.)

being intercepted rather frequently by official inspectors at California ports on ships from Hawaii, the importance of cooperation by all in making the quarantine of the Federal Horticultural Board a success in keeping out this very serious pest will be readily appreciated.

WHAT THE MELON FLY IS LIKE.

The melon fly, like other so-called "fruit flies," is similar to the ordinary house fly in some respects; the adult lays small white eggs from which hatch larvæ, or maggots, which when full grown transform into pupæ. Later the adult emerges from the pupa, as the butterfly does from the chrysalis, and the cycle of life—adult, egg, larva, pupa—is repeated with each successive generation. Figure 1 shows an adult melon fly about to lay eggs in the bud of a watermelon. Note the relative size of the fly and the bud. The adult female, greatly enlarged, is shown in figure 2. When it is remembered that the adult is from one-fourth to one-third of an inch long, that its body is of a yellowish to a yellowish-brown color,



FIG. 2.—Adult female of the melon fly. Greatly enlarged. (Authors' illustration.)

and the markings between the wings, which appear white in the figure, are bright canary yellow in the living insect, and that the wings are banded with dark brown, it will not be difficult to recognize this pest.

The female fly drills small, pinhole-like openings in the skin of vegetables with the sharp tip of her body, called the ovipositor. Through these punctures she lays her white eggs, which are about one twenty-fifth of an inch long. If a small squash flower be cut open after the female fly has laid her eggs, a small cavity containing the eggs, such as is illustrated by figure 3, is shown. The larvæ, or maggots, that hatch from the eggs feed in various parts of the host plant. They have two black hooklike processes in the head that serve as jaws in aiding them to break up their food and to force their way

through the plant tissues. But as the larvæ, even when full grown, are only about two-fifths of an inch long, a detailed description of them is of little value. It is enough to know that they differ very little from the ordinary white maggots, of equal size, with which the reader is doubtless familiar. The larvæ when full grown leave the host to transform to the pupa stage just beneath the surface of the soil, or beneath any protecting object. They even may transform to the pupa within the host fruit, but this is a rare occurrence. Figure

4 shows larvæ and pupæ about twice natural size. In figure 6 are shown well-grown larvæ feeding in the root of a young watermelon plant. Figure 5 represents an enlarged larva.

As the melon fly usually first forces itself upon the attention of the market gardener by the damage it does, it is more important to be able to recognize it by its work than by a mere description of the different stages. The reader, therefore, is directed particularly to the illustrations, for, besides showing types of injury, they make clear that it is in the larva stage that the melon fly causes its greatest damage.

ORIGIN AND DISTRIBUTION.

The original home of the melon fly is the Indo-Malayan region. At present it is known to occur in various parts of India, in Ceylon, Java, Macao, Timor, northern Australia, about Singapore, in southern China at Canton and Hongkong, in the Philippine Islands, in Formosa, and in the Hawaiian Islands. There is some doubt at present about its occurrence at Nagasaki, Japan.

It is believed that the melon fly was introduced into the Hawaiian Islands at Honolulu from Japan or China. It probably arrived in the larva stage in vegetables brought along as food from Japan by Japanese coolies emigrating as steerage passengers to work on the sugar plantations in Hawaii.

ESTABLISHMENT AND SPREAD IN HAWAII.

The melon fly was first observed in Hawaii, so far as records show, by Mr. Byron O. Clark, who, during October to December, 1897, found it almost impossible to grow cucumbers, squashes, melons, and similar vegetables in the Kalihi district of Honolulu and about Pearl City. During August, 1898, the pest already was established at Lau-

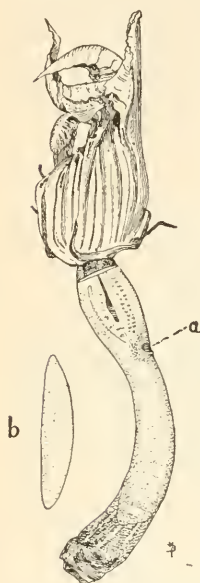


FIG. 3.—The melon fly: *a*, Eggs deposited in cavity in young pumpkin flower; *b*, single egg, much enlarged. (Authors' illustration.)

pahoehoe, Island of Hawaii. Indications are that the melon fly was introduced as early as 1895.

That the melon fly is an introduced pest is proved by the interesting fact that the gourd calabashes used by the Hawaiian natives during the past century, many of which are preserved in various



FIG. 4.—Melon fly: *a*, Well-grown larvæ; *b*, puparia. Twice natural size. (Original.)

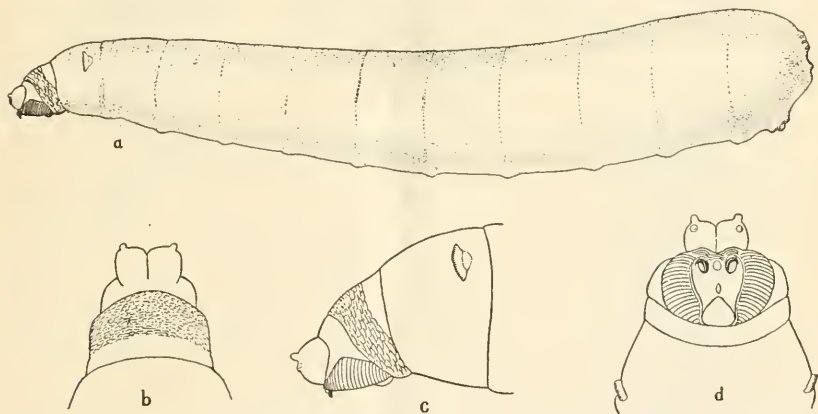


FIG. 5.—The melon fly: Third-instar larva. *a*, Lateral view of entire body; *b*, dorsal view of anterior end; *c*, *d*, lateral and ventral views of same. Much enlarged. (Authors' illustration.)

museums and private collections, are free from evidences of melon-fly attack. Modern utensils largely have superseded calabashes during these later days, but the few that are grown show the surface defects due to the attack of the melon fly.

Although no satisfactory record has been made of the spread of the melon fly to the various islands of Hawaii, it is now a well-



FIG. 6.—1, Watermelon seedling destroyed by larvæ of melon fly feeding in taproot, crown, and leaf petioles; 2, work of larvæ in root, enlarged. (Authors' illustration.)

established and serious pest throughout all the coastal regions. It has been known even to attack cucumbers and squash at altitudes ranging up to 4,000 or 4,500 feet.

METHODS OF SPREAD.

The melon fly probably is carried more often from one locality or country to another in the larva stage than in any other form. Quarantine officials at San Francisco have found living larvæ in host fruits arriving at San Francisco on ships from Honolulu, and records prove that the melon fly in the larva stage is able to bridge the six or seven days required by the slower vessels to cover the 2,000 miles between the Hawaiian Islands and California, since infested fruits have been intercepted and condemned at least once a year since 1912. Host fruits taken on board ships as ship's stores are capable of carrying the melon fly as larvæ, or later as pupæ, in the fruit containers, for voyages occupying a longer time than is required to cross the Pacific Ocean, and thus may become a factor in spreading the pest through vessels plying between almost all countries where climatic conditions are favorable for the establishment of the fly.

The spread from one country to another at a considerable distance probably starts with the fly in the larva stage, but the spread from town to town, or over short distances, as between islands of the Hawaiian group, may occur in the adult or pupa stage. A female fly has been observed to alight on an automobile top and be carried 16 miles from the country into the city of Honolulu. On another occasion an adult was seen flying about an interisland boat en route from Honolulu to Hilo, on the island of Hawaii. This fly was not observed after the boat weighed anchor at the port of Lahaina, on the island of Maui, or 72 miles from Honolulu. These two instances will explain the spread of the pest, in the adult stage, about the islands of Hawaii, even if it could not be transported in the larva stage.

When larvæ form their puparia on bare surfaces, and particularly on a cloth surface, the puparia may adhere sufficiently well to make it possible for them to be transported considerable distances under favorable circumstances. Although no definite instances are known where the melon fly has been spread thus, distribution in this fashion is quite feasible and to be expected.

ECONOMIC IMPORTANCE.

The melon fly is the most important pest of varieties of melons, squashes, and cucurbits in general grown in the Hawaiian Islands, and probably elsewhere. Its persistent attack has caused many persons to abandon the growing of the more susceptible host fruits.

Other fruits can be grown for the most part only under cover and at increased cost. The unrestricted cultivation of fruits and vegetables in Hawaii has been ruined by the melon fly and the Mediterranean fruit fly. Though the latter is probably the more to be feared, many



FIG. 7.—Older squash vine with abnormal growths due to work of melon-fly larvæ. (Authors' illustration.)

persons regard the melon fly as of greater importance from an Hawaiian standpoint, for it attacks with the greatest persistency such crops as squashes, pumpkins, vegetable marrows, tomatoes, and beans, all of which could furnish under the ideal Hawaiian climatic conditions an abundance of food for the poorer people. Such vegetables as muskmelons, watermelons, pumpkins, squashes, and tomatoes can not be grown to-day in many parts of the islands unless the plants are screened carefully.

Cantaloupes and watermelons, instead of being common and cheap delicacies, as in former years, are now a luxury for even the wealthy. Cantaloupes, once grown in large quantities about Honolulu, now are imported from California. It is no longer possible to grow pumpkins as stock food on idle land. Quarantines prohibit the export of early shipments of egg-plant, bell peppers, and tomatoes, thus shutting off an income formerly enjoyed by the small farmer. The loss to market gardeners in Hawaii as a result of melon-fly attack has been placed conservatively at three-fourths of a million dollars annually. It is not possible to exaggerate the importance of the melon fly as a serious pest under Hawaiian coastal conditions.

NATURE OF INJURY CAUSED BY THE MELON FLY.

The melon fly does not confine its attack to the fruits of its host or food plants. It may attack the young seedling, the flower, the root, the stem, or the fruit.

INJURY TO SEEDLING PLANTS.

The melon fly attacks with severity the young succulent seedling plants of watermelon and cantaloupe. The female fly lays her eggs in

the crown of the plant, and the larvæ, on hatching, feed there first. They later burrow down into the taproot and upward into the petioles of the leaves, and even into any young runners that are forming. The capacity of the melon fly for injuring a watermelon seedling is shown in figure 6 (p. 6). The enlarged figure of the root shows four full-grown larvæ eating their way into the root. In the figure of the seedling the larvæ have almost severed the leaf to the left, and have tunneled completely through one of the petioles and so destroyed it that the weight of the leaf has caused its stem to break over. Injury to a seedling runner is shown in figure 8. In certain places in Hawaii where the melon fly is very abundant, entire



FIG. 8.—Seedling watermelon showing runner killed back by burrowing melon-fly larvæ.
(Authors' illustration.)

fields of watermelons may be killed before the plants can develop runners. Squash, pumpkin, cucumber, tomato, and bean seedlings almost never are attacked. Larvæ never are found in the roots of older plants.

INJURY TO THE STEM.

As the plant becomes older, it is still subject to attack. The female fly lays her eggs in the rapidly growing pumpkin and squash vines, but the larvæ after hatching do very little damage, although they are able to mature. They often cause abnormal swellings or cancerlike spots where a colony of them are feeding, as illustrated by figure 7; but if the injury threatens the stem, the plant throws out roots on either side of the part affected to offset the damage. Such attacks upon the stem are not of importance, except in the case of watermelon and cantaloupe.

But in the two plants last mentioned the injury resulting from attack upon the stems may be very serious, and in many cases cause a complete failure of the crop. Figure 9 shows a portion of a canta-



FIG. 9.—Cantaloupe vine attacked by melon fly in eight places, including stalk, leaf petioles, and young fruit. (Authors' illustration.)

loupe vine that has been attacked in eight places. So persistent is attack upon cantaloupe in Hawaii that the vine can not be grown satisfactorily except in isolated spots or under cover.

Figures 1 and 10 show a common condition found in watermelon fields. The female fly usually chooses the growing tip of the runners in which to lay her eggs. In making a place in the vine for her eggs she practically severs the tip of the vine so that it may fail to grow

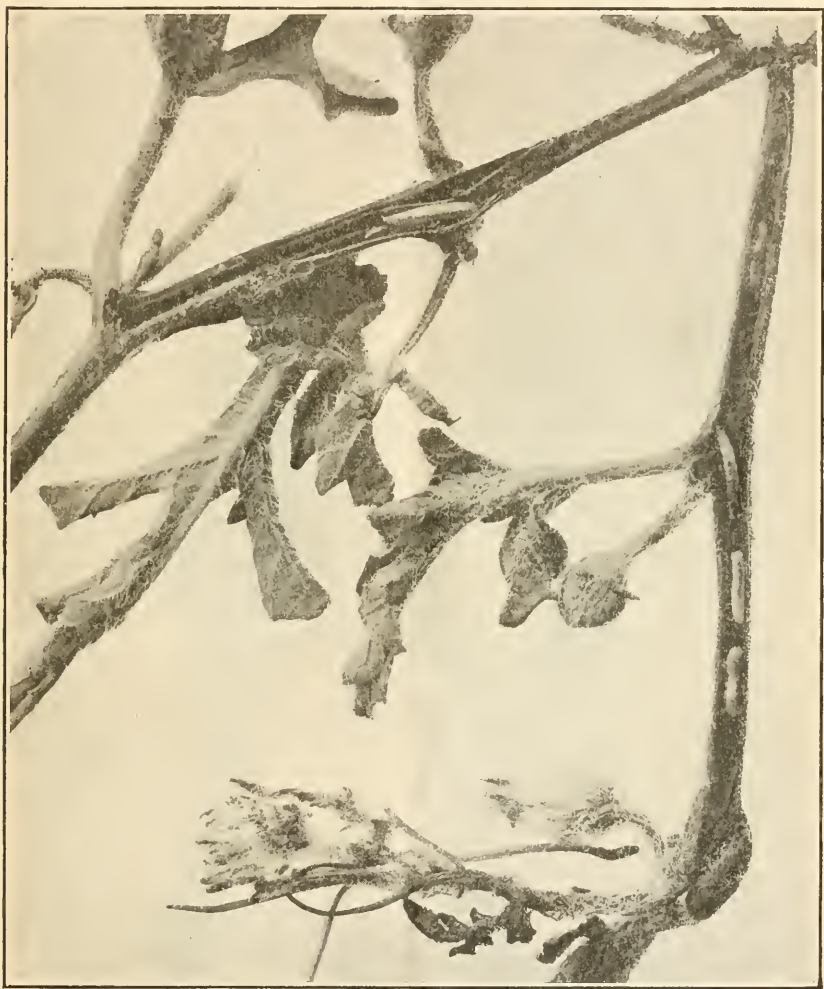


FIG. 10.—Succulent watermelon vine sectioned to expose five well-grown larvæ of the melon fly which have eaten out the interior, causing the vine to wither and die back to the point of original infestation. (Authors' illustration.)

beyond the point of injury. The growing end of the vine, however, usually is ruined, for, if the egg-laying process does not cause serious damage, the larvæ hatching, numbering from 2 to 10, begin to feed and bring about a hasty destruction. Figure 1 shows the drooping,

withered, growing tip. In this case the eggs were laid just beyond the leaf and flower stalks.

When the eggs are laid in the older though still very young and succulent watermelon vine, the larvæ, on hatching, tunnel their way

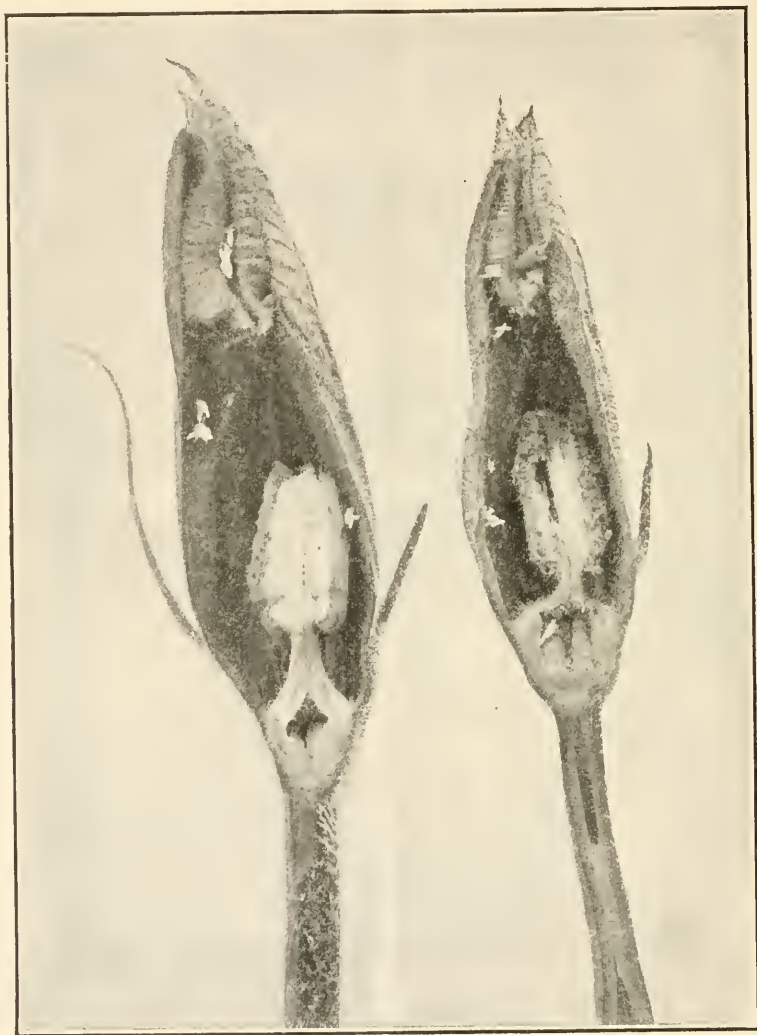


FIG. 11.—Melon-fly eggs in blooms of pumpkin. Two buds of the male bloom sectioned to show the eggs deposited through the corolla. (Authors' illustration.)

through the vine, eating out the center and causing it to wilt and die. Figure 10 shows a vine sectioned to expose the five well-grown larvæ which have killed it beyond the base of the leaf in the upper left-hand corner of the illustration. The serious setback to vine develop-

ment that this type of injury causes is readily apparent. Such pruning back of the vines, repeated over and again, may prevent the formation of sufficient growth for the development of fruits.

INJURY TO THE BLOOM.

Although injury to the seedling plant and to the growing stem is greatest in watermelon and cantaloupe and is of little importance among squashes, cucumbers, and pumpkins, the injury to the bloom is very serious among all these crops except that of the cucumber. Among pumpkins and squashes both the male and female blooms are affected; but among the watermelons, cantaloupes, chayotes, and Chinese marrows the male or staminate bloom escapes attack. It is not uncommon to examine luxuriantly growing fields of squashes and pumpkins during the warm months and not find a single unaffected bloom. Uninformed growers often question why their vines set no fruits. The condition of the blooms illustrated in figures 11 to 14 is the answer.

The unfertilized ovaries of all cucurbit blooms are especially attractive to female melon flies. The flies lay eggs in the undeveloped and unfertilized ovaries of the bloom before the blossom unfolds, and the larvæ, on hatching, often so ruin the ovaries, as indicated by their burrows shown in figure 12, that the flower never unfolds. In those varieties having long, narrow fruits the ovaries are many times so eaten out and decayed that the weight of the upper part of the bud causes the ovary to break (see fig. 13). So complete is the destruction



FIG. 12.—Work of melon-fly larvæ in bringing about destruction of ovaries of pumpkin bloom even before the corolla has entirely withered.

of the ovaries of watermelon bloom that in dry weather the remains of the bloom wither and become mummified, as shown in figure 15.

An examination of the buds of the male bloom in any field throughout the coastal regions of the Island of Oahu, particularly during the months from March to November, will reveal the severity of attack centered on this portion of the plant.

Wherever the buds have been attacked, a whitish gumlike excretion exudes which hardens about the point of attack. On cutting the buds lengthwise, batches of eggs can be seen among the folds of the corolla, or in the stamens and receptacle, as shown in figure 11 (p. 12). As the eggs are pure white and are in clusters of 2 to 10 or more, they are seen easily without the aid of a lens. If the eggs have been laid from 2 to 6 days, the inside of the bud may have been already eaten out by the rapidly developing larvæ. Buds attacked before they are half grown usually are destroyed completely before the blossom unfolds. Figure 14 shows three stages in the destruction of the staminate bloom. The bud *a* is a mass of decay within; the stamens have been devoured and the larvæ already have begun to burrow about the base; *b* shows a bud that has been severed by the feeding of the larvæ and has fallen over under its own weight; and *c* is the upright stem of the bud, after the essential parts of the bloom have been ruined and have fallen to the ground. Although attack may occur so late in the development of the male bloom that the corolla can unfold, it is more often than not that eggs, or even young larvæ, can be seen on the inside of the corolla when the flower is in full bloom. The melon fly never attacks the bloom after the corolla has unfolded.



FIG. 13.—Pistillate bloom of squash in which larvæ of the melon fly have so devoured the unfertilized ovary that the bloom is destroyed before the flower can unfold. (Authors' illustration.)

INJURY TO NEWLY SET FRUITS.

The greatest destruction among fruits usually occurs when they are very young, either before they are fertilized or just after they have set. At this stage of development the young fruits are expanding very rapidly. Figure 16 shows the damage done to three young pumpkin fruits. About the damaged areas calluses are formed by the fruit in an attempt to repair the damage, but this attempt seldom

prevents secondary decays from starting, and these bring about the destruction of such portions as escape the larvæ. The sectioned pumpkin in figure 17 shows how a colony of larvæ may eat into a young fruit, become full grown, and leave it without causing a complete destruction. It also shows how smaller, weaker colonies may develop in the outer portion of the pulp.

INJURY TO OTHER FRUITS.

Complete destruction of fruits by larvæ of the melon fly rarely occurs after they have become 4 to 5 inches in diameter, for then

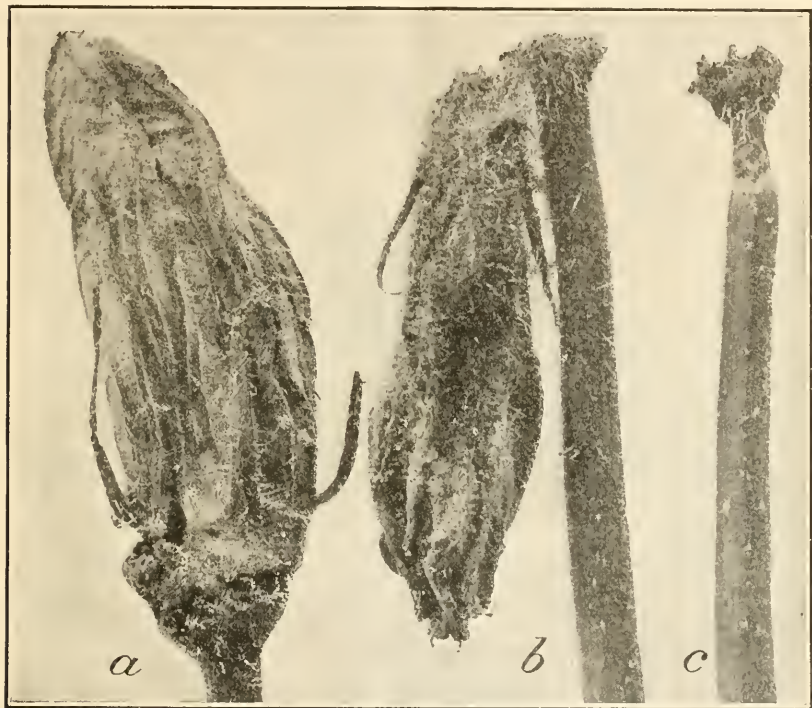


FIG. 14.—Buds of male flowers of pumpkin damaged by larvæ of melon fly, *a*, *b*, and *c* representing various stages in the destruction of the bloom. (Authors' illustration.)

the portion of the fruit containing the seeds, or the part preferred by the larvæ, is well protected by the outer meaty pulp and by the rind. Such colonies of larvæ as are then able to become established in pumpkins and squashes usually develop in the outer portions of the fruit and do not penetrate to the center. In cantaloupes, watermelons, cucumbers, and marrows, however, the larvæ more easily may work their way down to the softer, central portions and there complete their development, while the outer portion of the fruit remains quite firm. Figure 19 (p. 20) shows the cross section of a watermelon that had the general external appearance of being sound.

Yet, when cut open, it was found that its center had been eaten away entirely and the well-grown larvæ had made tunnels, shown somewhat reduced, throughout the rind.

Numerous similar examples of destruction might be described. But it is important to remember the fact that melon-fly attack upon the older fruits is far more likely, except in the case of the cantaloupe, cucumber, and tomato, to result in larval development in open

surface wounds and in deformities.



FIG. 15.—Section of watermelon vine, showing two fruits so devoured by larvæ of the melon fly that they have become mummified during dry weather following attack. Note that the remains of the blossom still persist. (Authors' illustration.)

One of the squashes of figure 21, the cucumbers of figure 18, and the watermelon of figure 20 illustrate types of deformities very common in Hawaii. Wherever the fruits have been only slightly damaged by melon-fly attack, deformities result. It is seldom that a perfectly formed cucurbit is seen in the markets of Honolulu unless the fruit was grown under protective coverings. Although deformities do not completely ruin the fruit, they restrict development and prevent the fruit from reaching its

normal size, as illustrated by the unaffected squash and the badly deformed squash of figure 21 (p. 22). Cucumbers and watermelons so badly deformed as those shown in figures 18 and 20 are not salable, even though they contain no larvæ. The purchaser of fruit has learned from experience that deformed cucumbers must be viewed with suspicion, for, although they may be fit for the table, they may contain maggots.

FOOD OR HOST PLANTS.

The food or host plants of the melon fly may be divided into those preferred and those occasionally infested and may be listed as follows:

CULTIVATED.

Preferred.

- | | | |
|----------------|--------------------------|-------------------|
| 1. Cantaloupe. | 6. Chinese cucumber | 10. Tomato. |
| 2. Watermelon. | (<i>Momordica</i> sp.). | 11. String beans. |
| 3. Pumpkin. | 7. Chinese melon. | 12. Cowpeas. |
| 4. Squash. | 8. Chayote. | |
| 5. Gourds. | 9. Cucumber. | |

Occasionally infested.

- | | | |
|--|------------|-----------------------------|
| 1. Eggplant. | 3. Orange. | 6. Peach. |
| 2. Water lemon (<i>Passiflora</i> sp.). | 4. Fig. | 7. Mango. |
| | 5. Papaya. | 8. <i>Citrullus</i> (Java). |

WILD.

- | | |
|---------------------|-------------------------|
| 1. <i>Sycos</i> sp. | 2. <i>Momordica</i> sp. |
|---------------------|-------------------------|

Erroneously recorded host fruits.

- | | | |
|--------------|-------------|-------------|
| 1. Kohlrabi. | 2. Cabbage. | 3. Peppers. |
|--------------|-------------|-------------|

CUCURBITACEOUS PLANTS.

All the cucurbitaceous plants are subject to severe infestation, particularly of the young fruits. Cantaloupes are the most susceptible, since the vines as well as the fruit are attacked badly at all stages of growth, and the fruits do not appear to develop the resistance to attack found among the older watermelons, pumpkins, and squashes. Ordinarily the cucumber is resistant to attack when very young, although it is rare that cucumbers offered for sale in Honolulu do not show some evidence of attack, even when very carefully collected. Cantaloupes and cucumbers may be used successfully by the female fly for egg laying up to the time



FIG. 16.—Various deformities of very young pumpkins caused by infestations started before or just after fertilization of the ovary. These fruits persist for a time, owing to calluses developing about points of attack, but they never reach a much larger size and are ultimately destroyed by fungi and secondary attack. (Authors' illustration.)

they are ready for market. Although cantaloupe growing has been abandoned practically in Hawaii since the advent of the melon fly, cucumbers are grown without protection of any sort. Practically all fruits reaching a size fit for salad use show evidences of attack at one

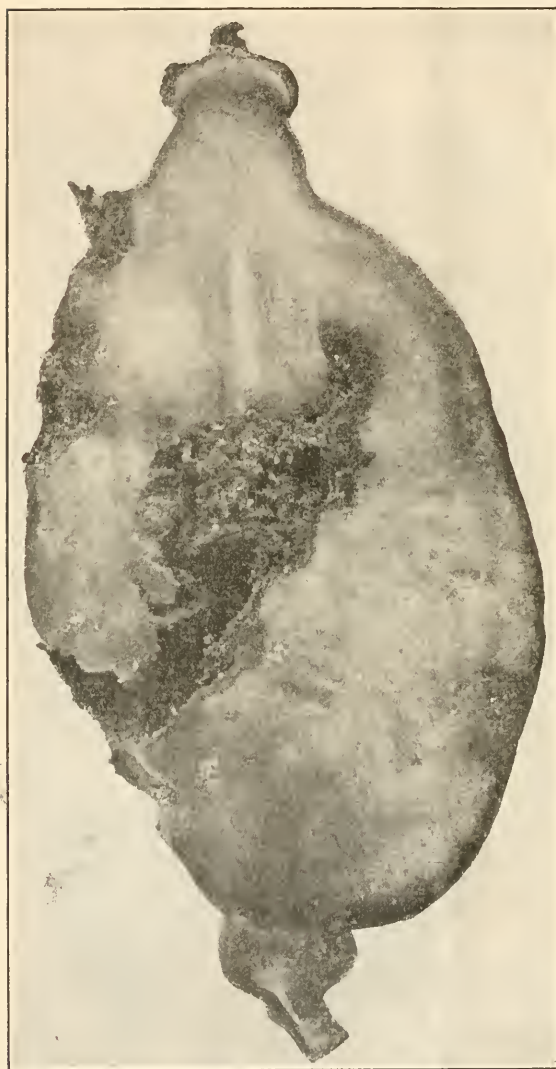


FIG. 17.—Cross section of young pumpkin, showing work of larvæ of melon fly. Each affected area represents the location of a colony of larvæ. (Authors' illustration.)

or more spots, but the percentage of fruits rendered unmarketable is not large enough to force the oriental growers to cover the young fruits, although it would appear disastrously large to American market gardeners, who place a high value on their time. During midwinter 150 out of 153 cucumbers, ready for the market at Moiliili, were found infested variously.

All cucurbits grow with such rapidity in Hawaii that the oriental is willing to permit the pest to destroy fully 50 per cent of the fruits rather than go to the expense of covering each fruit as soon as or before it sets. To prevent wholesale injury, all cucurbits except cucumbers must be covered before or just after blooming.

Aside from the fact that the seedlings and vines of all cucurbits except cantaloupe and watermelon are attacked but slightly, there is little difference in the susceptibility to attack of the young fruits under

Hawaiian conditions. Inasmuch as the fly has been permitted to increase unchecked since its introduction, it has become so abundant that slight differences in inherent resistance to attack are not evident

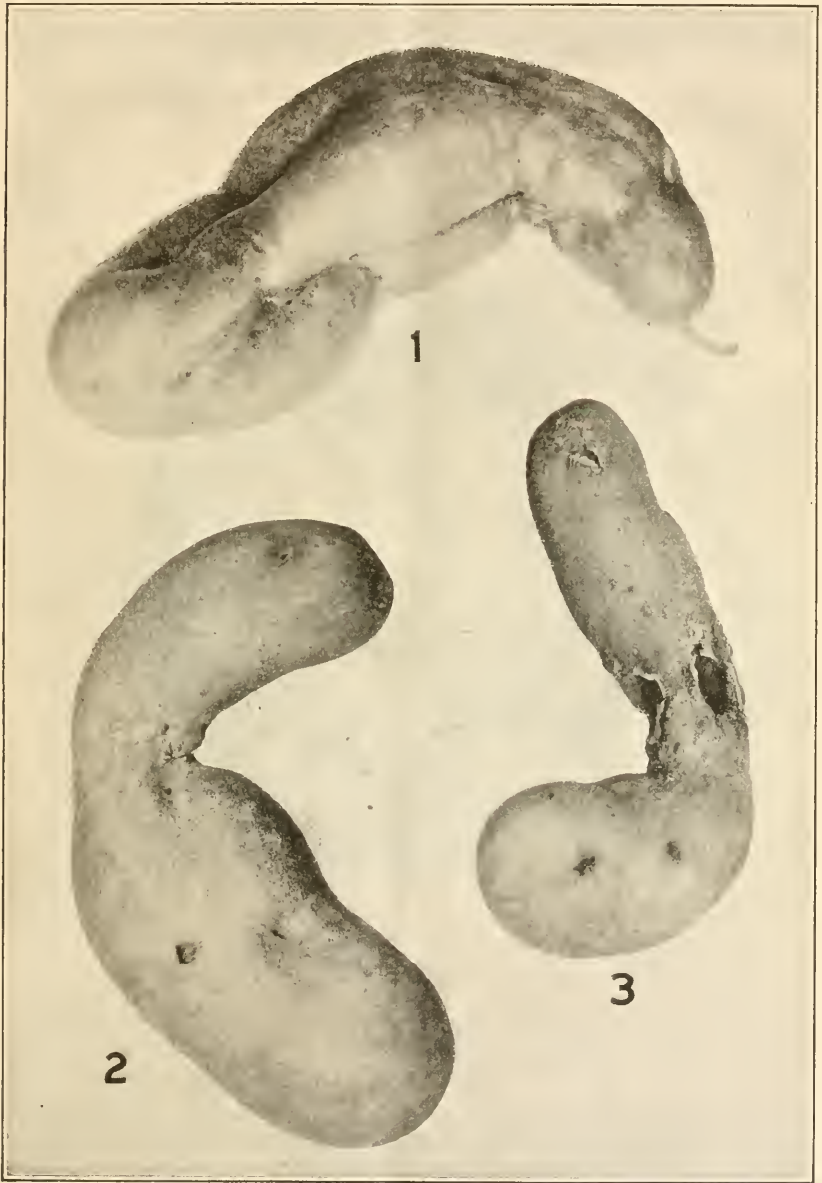


FIG. 18.—Damage to cucumbers by larvæ of melon fly. (Authors' illustration.)

among host fruits growing in the field. The infestation is excessive in all unprotected fruits. If by chance pumpkins, squashes, and watermelons escape infestation until they are from 4 to 6 inches

in diameter they may reach maturity, although before they reach maturity pumpkins and squashes may support numerous colonies of larvæ in open surface wounds and become badly deformed. Out of 254 nearly full-grown pumpkins growing at Kahuku during the winter months, 250 were found variously deformed. As many as 650 adults have been reared from a pumpkin not more than 4 inches long; the staminate bloom while still a bud may support as many as 37 well-grown larvæ.

TOMATOES.

Tomatoes are very susceptible to attack. All tomatoes offered for sale in Honolulu are likely to be infested, as shown by the reports of



FIG. 19.—Cross section of young watermelon, showing destruction of interior by larvæ of melon fly. Reduced one-fourth. (Authors' illustration.)

the market fruit-fly inspector covering several months. Fifteen ripe or partly ripe fruits examined at Hauula on March 21, 1915, contained eggs or larvæ. Such severe infestation is so general during the warmer months that data are superfluous. Under climatic conditions less favorable for the increase of the melon fly the tomato probably would be found to be less susceptible to attack than cucurbitaceous crops. The fruits of the small wild tomatoes and the spiny yellow-fruited *Solanum*, common in Hawaii, all are found growing about fields of cucurbitaceous crops, but never yet have been found infested. During January and February fields of tomatoes may produce a large percentage of sound fruits, owing to the effect of the

cooler weather upon the activities of the fly. Only the fruits of the tomato are subject to attack.

STRING BEANS.

The ordinary varieties of string beans grown on the mainland as a rule are not infested by the melon fly. Of the variety commonly known as the Yellow Wax bean, 375 pods sufficiently ripe to have turned color were examined at Haleiwa and were found free from attack, although growing close to a field of badly infested pumpkins, in March. Examinations of string beans in other localities, particularly about Honolulu, indicate that seldom are any of the varieties infested except the more fleshy, long-podded Chinese variety. This variety may be attacked very badly when grown near other favored host fruits or on land recently cleared of such crops, as illustrated by figure 22. As many as 36 well-grown larvæ have been found within a single pod.

Although the Chinese variety is the only one at times generally and badly affected, beans of all varieties

except the Lima bean should be included in quarantine lists. The Lima bean never has been found infested. Only the pods of beans usually are infested. The larvæ prefer to feed upon the fleshy portions of the pod, but sometimes attack the seeds. In badly infested pods, attacked before the seeds are well grown, the larvæ may eat out the seeds and leave nothing but the outer portion untouched. This also is true of cowpeas.

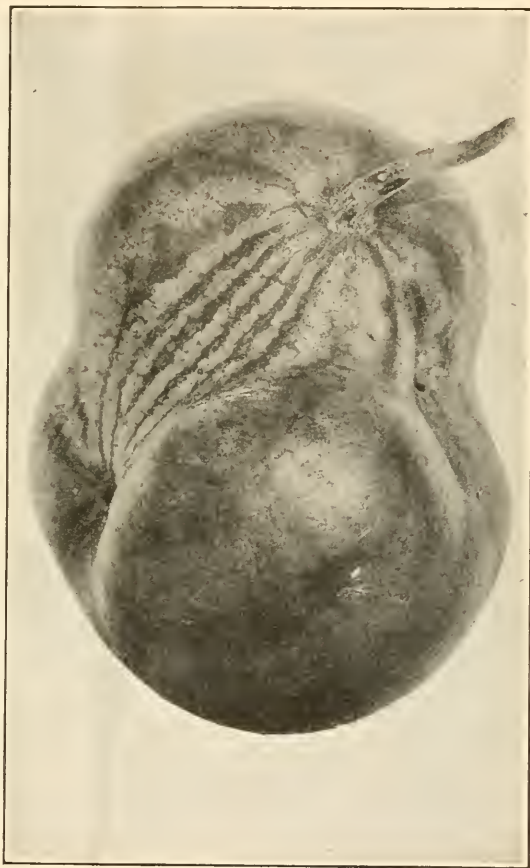


FIG. 20.—Deformed watermelon resulting from late infestation by larvæ of melon fly. (Authors' illustration.)

COWPEAS.

Although cowpeas are not grown to any great extent in Hawaii, they are subject to melon-fly attack. Only the pods are affected. As many as 37 larvæ have been taken from a single pod. When infestation occurs early the young seeds may be devoured, but attack is centered more often upon the pod itself. Some varieties of cowpeas appear to be less liable than others to attack by the melon fly.

FRUITS AND VEGETABLES THAT ARE SELDOM OR NEVER ATTACKED.

Several observers have stated that the melon fly attacks eggplant, bell peppers, cabbage, and kohlrabi. During a period of three years



FIG. 21.—Damage to squash by larvæ of melon fly. Of the two fruits illustrated, the one to the right is normal, and the one to the left, the stunted and deformed fruit caused by melon-fly attack. (Authors' illustration.)

the representatives of the department have not found any of these vegetables affected. The Mediterranean fruit fly has been found attacking eggplant and bell peppers, but only in small numbers. Even in the laboratory eggplant was found immune to melon-fly attack if the fruits were sound. Adult melon flies, however, were reared from fruits first weakened by decays.

Adults have been reared from orange, mango, fig, papaya, peach, apple, and water lemon. These

fruits, however, do not serve regularly as hosts of the melon fly. Only in rare instances does the melon fly attack them, and then only slightly. For practical purposes aside from quarantines all the fruits and vegetables listed under this subheading are free from attack by the melon fly.

INTERESTING FACTS CONCERNING THE ADULT FLY.

The most interesting facts about the adult melon fly center about the length of life and the capacity to lay eggs. No flies have been

known to live longer than $4\frac{1}{2}$ days without food and water, or longer than 5 days with water but no food. But if they can feed upon plant juices, such as the sap that exudes from cut or broken surfaces of pumpkin vines, cucumber fruits, papayas, etc., or the sap exuding from the breaks made in host plants during egg laying, adults may live many months. One female lived from February 17, 1914, to April 4, 1915, or $13\frac{1}{2}$ months. The length of adult life is variable



FIG. 22.—Destruction of green bean pods by larvæ of melon fly. In *a* and *b* a portion of the pods has been removed to expose larvæ and their work. In *a* are shown four well-grown larvæ. Pods in different stages of drying out after the larvæ have left them are shown in *c* and *d*. (Authors' illustration.)

under like conditions. From the standpoint of longevity the chief interest centers about the fact that certain adults may live long periods and thus keep the pest alive during seasons when host fruits are not in season.

Female flies may begin to lay eggs as soon as 14 days after they emerge from the pupa during the warmer months, when the mean temperatures range from 75° to 79° F. During the winter, at a mean

of about 71° F., many adults may not lay until 44 days after emergence. The season of the year and the nature of their food have an influence upon the rapidity with which eggs are formed.

But once the female fly begins to lay eggs, she may continue to do so throughout life. The largest number of eggs laid by any female in confinement is 687, but 1,000 probably may be laid by vigorous long-lived flies. While 37 is the largest number of eggs laid by a single individual during any one day, the number varies, and may be as few as 1. On many days no eggs are laid. Unlike the female of the Mediterranean fruit fly, which lays a few eggs almost daily, the female melon fly lays more eggs per day, but at greater intervals. Thus one fly deposited 14, 19, 13, 29, 16, 19, 16, 12, 17, 7, 9, 16, 7, 12, 37, 25, 24, 21, 28, 6, and 18 eggs, respectively, per day during the first three months (summer months) after depositing her first eggs; she laid no eggs in fruits until she was 51 days old, and, after she began laying, laid eggs on only 21 out of 90 days. During the seventh, eighth, and ninth months of her life (winter months) she deposited 10, 2, 18, 14, 15, 20, 13, 9, and 3 eggs.

Female flies can resume normal egg laying after periods of scarcity of host fruits. Females that have not been given an opportunity to lay eggs within fruits for periods ranging from 3 to 9 months after emergence have begun to deposit eggs at a normal rate as soon as fruits were placed with them in the laboratory rearing cages.

WHY THE MELON FLY IS A SERIOUS PEST.

The melon fly is a serious pest in Hawaii because it finds in the coastal areas a favorable climate and plenty of food. Regardless of the great discouragement due to its ravages, the oriental market gardeners, and others to a less extent, plant its host vegetation in rotation on the same or neighboring plats of ground. No attempt is made to prevent the flies from maturing in infested fruits. The decaying and infested fruits of the cucumber crop, for instance, are left on the field that is to be planted to tomatoes, or the flies developing from the cucumbers migrate to attack the melons just coming into bearing in the near-by field. No system of control, aside from covering successfully a small portion of the fruit that sets, is practiced.

It thus happens that large numbers of adults mature, and, as the climate is favorable, they multiply rapidly. During the warmest Hawaiian weather, when the mean temperature averages about 79° F., the egg, larva, and pupa stages may be passed in as few as 12 or as many as 29 days, according to the individual and its host. The complete life cycle is subject to great variation, according to the

longevity of the adult. Since one female fly has been known to live 431 days, it is evident that the complete life cycle from the laying of the egg to the death of the fly may be 443 to 460 days when the immature stages are passed during the warmer portions of the year. At an average mean temperature of about 68° F., which is the coolest temperature found in Hawaii where fruits are available in numbers for study, the immature stages are passed in 40 to 45 days. It is difficult to state just what the variation in the life cycle may be in colder climates, but it may range between 3 and 4 months.

This rapidity of increase throughout the coastal regions permits from 8 to 11 generations of the melon fly a year, when a generation is considered to extend from the time the egg is laid until the female of the next generation begins to deposit eggs. As the females are capable of living many months and of depositing eggs at frequent intervals throughout life, the generations become hopelessly mixed. It is possible for a female ovipositing on January 1 to be still alive and laying eggs the following January along with the progeny of 11 generations of her descendants. It is, therefore, small wonder that the melon fly, under such favorable conditions, swarms throughout the market gardens of Hawaii and leaves little unaffected that is not protected by man.

CONTROL MEASURES.

NATURAL CONTROL.

No agencies at present are working in the Hawaiian Islands to bring about, even periodically, a very large natural reduction in the abundance of melon flies. The mortality among the immature stages, or among the adults, is not sufficiently high to be of practical value, although sometimes 90 per cent of the larvæ may be found dead in certain decaying fruits.

In climates colder than that of the Hawaiian coastal areas mortality due to cold temperatures will play a particularly active part in reducing the pest. While the cooler weather of the winter months does prolong the period of development throughout the coastal regions, the long life of the adult flies and the capacity of females for continued egg-laying make it difficult for market gardeners to benefit to any marked extent from the effects of cool weather if they allow their fruits to remain unprotected. The cooler weather in the more isolated gardens holds down the number of adults and limits their activity to a fewer hours during the day when it is warm enough for them to attack fruits, and in this way makes possible greater success in saving fruits by the use of various protective coverings than follows the use of the same measures during the summer months.

PARASITES.

Hawaii has no native parasites that attack the melon fly, but the Hawaiian Board of Agriculture and Forestry has introduced a parasite from India. This parasite ¹ was introduced at Honolulu during the early part of 1916, and has been reared and distributed in large numbers, but it is not known yet whether it will check the ravages of the melon fly in a practical manner. It has become established, however, and promises to be useful.

ARTIFICIAL CONTROL.

Individual growers of vegetables in Hawaii are likely to be discouraged in the application of remedial measures for the control of the melon fly. Host fruits are grown in rotation in the numerous garden spots and market-garden areas chiefly by uneducated orientals, who do not appreciate the necessity for a united fight against the fly. The usual custom among these laborers is to permit infested fruits to decay in the field. In certain uncultivated areas the wild Sycos and Chinese cucumbers run wild and furnish fruits in which the melon fly can breed throughout the year, even though no cultivated crops are grown. This abundance of cultivated and wild host fruits, coupled with a climate favorable for rapid multiplication, produces many adult flies which spread in all directions to render valueless all remedial measures except those that involve protective coverings for the fruits.

It thus happens that no artificial control measures have been applied successfully in controlling the melon fly under Hawaiian conditions. The only means now employed to safeguard fruits is that of protecting the young fruits with some type of covering until they are large enough to withstand attack. Trapping adults has proved a failure, and killing them by spraying thus far has given poor results. If all growers would cooperate systematically (1) in the destruction of the eggs and larvæ by submerging infested fruits in water or by boiling and (2) in the destruction of the adults by spraying, the value of spraying with a poisoned bait and of covering the young fruits would be enhanced to a point where either might be sufficiently effective to be recommended as satisfactory. But so long as the cultivation of host plants is largely in the hands of orientals and others who do not appear to be amenable to instruction as modified by western standards, no relief can be expected.

SPRAYING.

Since adult melon flies do not deposit eggs for 2 to 4 weeks after emergence during the summer, and only after relatively longer periods

¹ *Opius fletcheri* Silv.

during the winter, but feed continuously throughout this period, it is evident that any spray that will kill them before they begin to lay eggs is valuable. A poisoned-bait spray, containing 5 ounces of lead arsenate in paste form, $2\frac{1}{2}$ pounds of brown sugar, and 5 gallons of water, is very effective in killing adults. This spray, used at the rate of 30 gallons to the acre, was applied by means of a knapsack sprayer. About 2 acres of Chinese melons and cucumbers in a field fairly well isolated, from the Hawaiian standpoint, which means that no host fruits were growing within 500 yards, were sprayed on May 21, 26, and 28, June 1, 4, 8, 14, and 23 during typical summer weather. Six hours after an application many adults were sluggish and flew with difficulty, but within 24 hours many dead adults could be found among the vines. Although the adults were lessened numerically by the spray, the young fruits were punctured as badly at the end of the experiment as at the beginning.

Although negative results have followed the use of poisoned-bait sprays in Hawaii, failure has been due to the peculiar conditions surrounding the fields sprayed that permit an influx of female flies. Under commercial conditions, where cantaloupes, pumpkins, and watermelons are grown in large quantities in fairly dry climates, it is reasonable to believe that sufficiently good results will follow the use of poisoned sprays to make their application practicable as a method of control.

DESTRUCTION OF INFESTED FRUITS.

Larvæ and eggs may be killed by submerging the infested portions of the plant in water, or by burying, boiling, or burning. Choice of method will depend largely upon the amount of fruit to be handled and upon local conditions. There is no surer way to kill all immature stages than to boil or burn the fruits. Burning is often expensive, and, when trash in compost holes is depended upon to furnish the fuel, is likely to be unsatisfactory, particularly where, as in Honolulu, the quantity of infested material is so great. Bringing infested fruits to the boiling point will kill all forms. The submerging of fruits in ordinary tap water for five days will either kill all larvæ and eggs or stop further development.

Burial in soil is a satisfactory method, provided the fruits are buried deep enough and cracks are prevented from developing in the earth above the fruits as the latter decay and settle. It must be remembered that just after transforming from the pupa the adults are so soft that they can force their way through very small openings. A crack in the soil extending down to the fruit, even though it be no wider than ordinary blotting paper, is still wide enough to allow the adults to reach the surface and thwart the purpose of fruit burial. Adults can not make their way through a foot

of well-tamped soil, but have been known to force their way through 2 to 3 feet of dry loose sand beneath which their pupæ had been buried.

Because burial and burning may be left to subordinates who may not have the interests of the owner so much at heart, boiling or submergence in water is more highly recommended. The larvæ will not injure cattle if the fruits are used as feed, but many larvæ may escape before they are eaten; hence this method of destruction is not recommended unless the fruits have a real value as a food.

PROTECTIVE COVERINGS.

The protection of fruits and plants by covering with soil, paper, or cloth is a great labor-consuming operation, yet this is the only method that will protect under present Hawaiian conditions. Even



FIG. 23.—Protecting cucurbits from attack by melon flies. Each fruit (in this case of *Momordica* sp.) is placed, immediately after it has been fertilized, within a long envelope made of newspaper. (Authors' illustration.)

as practiced to-day, less than 25 per cent of all fruits covered, except certain Chinese marrows, are actually saved from attack. In a slightly cooler climate than that of coastal Hawaii a high percentage of the fruits could be saved. As it is, the great attraction of the unfertilized ovaries of the bloom makes it difficult to put on coverings before the flowers are infested. During the warmer portions of the year the bloom of cucurbits, with the exception of the cucumber, should be protected at least three to four days before the flower unfolds. At present many fruits are covered, but rather indifferently and ineffectively. During April only 9 out of 43 fruits of the Chinese melon that had been covered were sound, while on the same date 119

out of 692 young protected watermelons were actually free from infestation.

Certain Japanese growers ward off attack by burying the young fruits in the soil or by surrounding them with straw or trash until they are sufficiently old to withstand fatal attack. In certain light soils cantaloupes are kept buried in the soil until they are ripe and they appear upon the market almost white in color. The most successful of protective coverings are those shown in figure 24. In this case the *Momordica* vines are grown over bushes, hence the young fruits can be found easily and inclosed in long cases made from newspapers and resembling envelopes cut across at both ends. These cases are left open at the lower end, but are never entered by the adult flies.

MEASURES TAKEN TO KEEP THE FRUIT FLIES OF HAWAII FROM GAINING A FOOTHOLD IN CONTINENTAL UNITED STATES.

The Federal Horticultural Board, by means of its Quarantine No. 13, entitled "Mediterranean Fruit Fly and Melon Fly," issued March 23, 1914, is doing all that man can do to prevent the two fruit-fly pests of Hawaii from becoming introduced into mainland United States. The regulations of the quarantine practically have put a stop to the movement of fruits and vegetables from Hawaii. Certain fruits and vegetables, however, such as bananas of the noncooking type, pineapples, taro, and coconuts, and others, when it can be shown to the satisfaction of the Department of Agriculture that in the form in which they are to be shipped they are not and can not be a means of conveying either the Mediterranean fruit fly or the melon fly, may be moved or allowed to move from Hawaii into or through any other State, Territory, or District of the United States when they have been inspected by the United States Department of Agriculture, certified to be free from infestation, and marked in compliance with the regulations. Pineapples, taro, and coconuts do not support the fruit flies of Hawaii, neither do bananas when shipped according to trade requirements. In practice the quarantine eliminates all shipments of fruit except the four just mentioned, and of these pineapples and bananas only are regularly shipped.

The enforcement of the quarantine is divided between the representative of the board in Hawaii and those at the ports of entry to the mainland, notably San Francisco, San Pedro, and Seattle. In Hawaii it is the duty of the inspector to see that the fruit is grown under conditions reasonably sanitary from a fruit-fly standpoint, that each package or bundle offered for shipment is inspected and bears a certificate to that effect, and that transporting companies do not re-

ceive for shipment consignments of fruit unless they have received from the Federal Horticultural Board a permit for such action. These permits, which give data on the kind, amount, and origin of fruit, the name and address of consignor and consignee, and dates, are issued in triplicate; the duplicate and triplicate remain in the files of the transporting company and the Federal Horticultural Board, respectively. The original is attached to the bill of lading accompanying the shipment and no consignment of fruit is permitted to leave the ship at the port of destination unless this permit is presented to the Federal inspector.

The duty of the inspector at the mainland ports is to make certain that no express or freight consignments leave ships arriving from Hawaii unaccompanied by the permit above mentioned, and that no quarantined fruits or vegetables are present either in the ship's lockers as ships' stores or in the possession of passengers, for all such are contraband after the ship passes within the 3-mile limit of the mainland. The inspector of the port of entry also must receive from each passenger a statement that he has in his baggage no contraband fruits or vegetables. Inspectors also have the right to search the personal belongings of passengers and members of the crew.

There seems little danger of fruit-fly pests reaching the mainland from Hawaii in commercial consignments of fruit since Quarantine No. 13 went into effect. *The greatest danger at present lies in the careless introduction of the pests by uninformed travelers who, without appreciating the great financial losses the Government is attempting to avert, persist in concealing about their persons and baggage contraband fruits, or in sending these by express or post in packages the contents of which are not stated truthfully.* These are the avenues of introduction that no law can close thoroughly. To close them, honesty and cooperation with the Federal Horticultural Board on the part of all are necessary.

SUMMARY.

The melon fly, a native of the Indo-Malayan region, is one of a number of very destructive pests that are likely to be introduced into the mainland United States. The quarantine officers of the Federal Horticultural Board and of California are each year intercepting it in infested fruits at California ports on ships from the Hawaiian Islands.

The melon fly was introduced into Hawaii about 1895 by Japanese immigrants in fruits which they brought with them as food from Japan. Before its arrival in Hawaii, cantaloupes, watermelons, tomatoes, and all kinds of cucurbitaceous crops, such as pumpkins, squashes, cucumbers, etc., were grown in large quantities and were

cheap. They could be grown in every dooryard. Because of the ravages of the pest, these crops can not be grown now by the average person, and only with great difficulty in market gardens. Many fruits must be imported, and the cost of all has been increased as a result of melon-fly attack. Even cowpeas and string beans may be infested. It is impossible to overstate the destructiveness of the melon fly to cucurbitaceous crops under Hawaiian coastal conditions, where none of these can be brought to maturity except with the exercise of the greatest care on the part of market gardeners.

Since there are as many as 8 to 11 generations of the melon fly a year, and the female flies may live to be over a year old and lay eggs throughout life, the pest can multiply very rapidly. No agencies have been found to be working at present in Hawaii that bring about, even periodically, a great natural reduction in the abundance of melon flies. No native parasites are known to attack the melon fly, but it is hoped that the parasite introduced from India during 1916 may prove effective. In colder climates cold weather will prove a marked and valuable control factor. Predacious enemies and several forms of mortality recorded are of no practical value under Hawaiian conditions.

No satisfactory artificial measures have been applied successfully in combating the melon fly under Hawaiian conditions. Poisoned-bait sprays promise to yield effective results under other cultural conditions. In Hawaii these sprays would be effective if they were used consistently and universally, but they are not. At present cucurbits can be grown only by the use of coverings of various sorts for the protection of the very young fruit. Killing the immature stages by submergence in water, by burial in soil, or by boiling are not applied as methods of control, although they are effective when intelligently applied. Artificial methods of control are not likely to prove satisfactory in Hawaii so long as the growing of the chief host plants remains in the hands of uneducated oriental laborers who do not practice clean cultural methods or cooperate in applying remedial measures.

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WM. A. TAYLOR, Chief

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PROFESSIONAL PAPER

January 18, 1918

LINT PERCENTAGE AND LINT INDEX OF COTTON AND METHODS OF DETERMINATION.

By G. S. MELOY, *Assistant, Crop Acclimatization and Cotton Breeding.*

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RELATION OF LINT PERCENTAGES TO LINT INDEXES.

The danger of reducing the vitality and earliness of cotton varieties and of breeding varieties with undesirable characters by over-emphasizing the percentage of lint as a measure of their comparative values was pointed out in 1908 by Mr. O. F. Cook.¹ It was suggested that the weight of the lint or fiber ginned from 100 seeds, instead of the lint percentage alone, be used as an additional standard for judging varieties. This standard of comparison was called the lint index. Subsequent experience has not only demonstrated the desirability of using this standard, but has led to the development of improved methods and devices for determining both the lint index and the lint percentage in experimental samples of seed cotton with which breeders have to work.

¹ Cook, O. F. Danger in judging cotton varieties by lint percentages. U. S. Dept. Agr., Bur. Plant Indus. Cir. 11, 16 p. 1908.

That a clearer understanding may be had of the relations between lint percentages and lint indexes in cotton varieties, as discussed in this paper, a brief definition of each is included, together with a word as to the adoption of these measures of cotton values.

LINT PERCENTAGES.

The percentage of lint, or lint per cent, as it is generally termed, is the relation between the weight of the fiber and the weight of the seeds from which the fiber is obtained in the process of ginning and is expressed as a percentage of the unginned seed cotton. A decrease in the weight of the seeds without a corresponding decrease in the weight of the fiber would alter this relation in the direction of increasing the percentage of lint. Conversely, an increase in the weight of the seeds without change in the weight of the fiber would result in a reduction in the percentage of lint.

The first commercial use of the percentage of lint was made by early operators of gins, who purchased cotton in the seed, ginned it, and resold the products. In those days, when the seed was considered a waste product, it was of especial importance to these gin operators to know the ultimate value of the seed cotton they purchased. The amount of fiber they might secure from a given weight of seed cotton, or the lint percentage, was the basis of such purchases. The emphasis laid upon the percentage of lint by these buyers of seed cotton naturally led to the belief among the growers that it was the chief factor or measure of value of varieties. To-day this relic of an admittedly bad method of selling cotton¹ is still accepted without question or apparent examination by planters and also by many of the breeders of cotton. The result is that inferior and unproductive varieties frequently have been planted merely because their lint percentages are high, while varieties that are superior both in productiveness and in quality of fiber have been rejected because their percentages of lint are considered low.

LINT INDEXES.

The lint index is the weight in grams of the fiber produced by 100 seeds and may be said to be a measure of the abundance of the fiber rather than a measure of the relation between the weight of the fiber and the weight of the seed, as is the percentage of lint.

Through years of association, the general cotton-growing public has come to consider a lint percentage of 33½ a basis of credit for a variety of cotton. So, in time, breeders may determine a basic lint

¹ Creswell, C. F. Disadvantages of selling cotton in the seed. U. S. Dept. Agr. Bul. 375, 18 p. 1916.

——— Losses from selling cotton in the seed. U. S. Dept. Agr., Farmers' Bul. 775, 8 p. 1916.

index, a departure from which will be considered an indication of either merit or demerit for a variety. The better varieties of Upland long-staple cottons have been found thus far to have a lint index of 5 to 6, and the better varieties of Upland short staples a lint index of 7 to 8. Varieties have been examined which were found to have a lint index as low as 4, and one variety was seen with a lint index of 9.50.

In order to facilitate the finding of lint indexes Table I has been prepared, in which the lint indexes, corresponding with various weights of seed and percentages of lint, are given. This table probably covers the range of commercial varieties. In using it the percentage of lint and the weight of 100 seeds of the variety or selection are first ascertained; then the lint index may be found in the column under the lint percentage, opposite the weight of the seeds. For example, a variety in which the seeds weigh 12 grams per hundred and which gins 35 per cent of lint will have a lint index of 6.46; that is, the lint ginned from 100 seeds will weigh 6.46 grams.

TABLE I.—*Lint index of a sample of cotton when the weight of 100 seeds and the percentage of lint are known.*

[Formula: Weight of seed ÷ percentage of seed × percentage of lint = lint index.]

Weight of 100 ginned seeds.	Percentage of lint.																			
	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42		
	<i>In-</i>	<i>In-</i>	<i>In-</i>	<i>In-</i>	<i>In-</i>	<i>In-</i>	<i>In-</i>	<i>In-</i>	<i>In-</i>	<i>In-</i>	<i>In-</i>	<i>In-</i>	<i>In-</i>	<i>In-</i>	<i>In-</i>	<i>In-</i>	<i>In-</i>	<i>In-</i>	<i>In-</i>	<i>In-</i>
	<i>der.</i>	<i>der.</i>	<i>der.</i>	<i>der.</i>	<i>der.</i>	<i>der.</i>	<i>der.</i>	<i>der.</i>	<i>der.</i>	<i>der.</i>	<i>der.</i>	<i>der.</i>	<i>der.</i>	<i>der.</i>	<i>der.</i>	<i>der.</i>	<i>der.</i>	<i>der.</i>	<i>der.</i>	<i>der.</i>
4.0 grams.....	2.00	2.10	2.24	2.33	2.45	2.57	2.69	2.82	2.95	3.09	3.23	3.37	3.52	3.68	3.83	4.00	4.16	4.34		
4.5 grams.....	2.16	2.28	2.40	2.53	2.65	2.78	2.92	3.06	3.20	3.35	3.50	3.65	3.81	3.98	4.15	4.33	4.51	4.71		
7.0 grams.....	2.33	2.46	2.59	2.72	2.86	3.00	3.14	3.29	3.45	3.61	3.77	3.94	4.11	4.29	4.47	4.67	4.86	5.07		
7.5 grams.....	2.50	2.63	2.77	2.92	3.06	3.21	3.36	3.53	3.69	3.86	4.02	4.21	4.40	4.60	4.80	5.00	5.2	5.44		
8.0 grams.....	2.66	2.81	2.96	3.11	3.27	3.43	3.59	3.76	3.94	4.12	4.31	4.50	4.69	4.91	5.11	5.33	5.56	5.80		
8.5 grams.....	2.83	2.98	3.14	3.30	3.47	3.64	3.82	4.00	4.19	4.38	4.58	4.78	4.99	5.21	5.44	5.67	5.91	6.15		
9.0 grams.....	3.00	3.16	3.32	3.50	3.67	3.85	4.04	4.23	4.43	4.63	4.85	5.06	5.28	5.52	5.75	6.00	6.25	6.52		
9.5 grams.....	3.16	3.33	3.51	3.69	3.88	4.07	4.27	4.47	4.68	4.90	5.11	5.34	5.58	5.82	6.08	6.34	6.60	6.88		
10.0 grams.....	3.33	3.51	3.69	3.89	4.08	4.28	4.49	4.71	4.92	5.15	5.39	5.62	5.87	6.13	6.39	6.67	6.95	7.24		
10.5 grams.....	3.50	3.69	3.88	4.08	4.28	4.50	4.71	4.94	5.18	5.41	5.65	5.91	6.17	6.43	6.71	7.00	7.30	7.60		
11.0 grams.....	3.67	3.86	4.07	4.28	4.49	4.71	4.95	5.18	5.42	5.67	5.93	6.18	6.45	6.75	7.03	7.35	7.65	7.98		
11.5 grams.....	3.83	4.02	4.25	4.47	4.69	4.93	5.17	5.41	5.67	5.92	6.19	6.48	6.76	7.05	7.36	7.68	8.00	8.33		
12.0 grams.....	4.00	4.21	4.43	4.67	4.90	5.14	5.38	5.64	5.91	6.17	6.46	6.75	7.05	7.35	7.67	8.00	8.33	8.68		
12.5 grams.....	4.16	4.36	4.62	4.86	5.11	5.36	5.62	5.88	6.16	6.43	6.74	7.03	7.33	7.67	8.03	8.34	8.68	9.05		
13.0 grams.....	4.33	4.58	4.81	5.05	5.30	5.57	5.84	6.11	6.41	6.71	7.00	7.30	7.63	7.97	8.35	8.66	9.04	9.40		
13.5 grams.....	4.50	4.74	5.00	5.23	5.51	5.77	6.07	6.35	6.65	6.95	7.26	7.59	7.93	8.27	8.62	9.00	9.37	9.77		
14.0 grams.....	4.68	4.91	5.17	5.45	5.71	6.00	6.29	6.58	6.89	7.21	7.54	7.88	8.22	8.58	8.94	9.35	9.73	10.01		
14.5 grams.....	4.83	5.10	5.36	5.63	5.92	6.21	6.51	6.82	7.13	7.47	7.80	8.15	8.52	8.89	9.26	9.65	10.06	10.50		
15.0 grams.....	5.00	5.27	5.55	5.83	6.12	6.43	6.74	7.06	7.38	7.72	8.06	8.43	8.81	9.19	9.58	10.00	10.16	10.33		
15.5 grams.....	5.17	5.45	5.73	6.03	6.33	6.54	6.97	7.29	7.63	7.97	8.35	8.72	9.10	9.50	9.91	10.33	10.76	11.22		
16.0 grams.....	5.33	5.62	5.92	6.22	6.53	6.86	7.19	7.52	7.88	8.24	8.61	9.00	9.38	9.81	10.22	10.66	11.11	11.57		

ILLUSTRATIONS OF THE RELATION BETWEEN LINT PERCENTAGE AND LINT INDEX.

A few examples of possible combinations of characters that may be found in varieties, as shown in Table I, are here given to illustrate the relation between lint percentage and lint index.

The lint index given for a seed weight of $13 + 25$ per cent is practically identical with that given for a seed weight of $6 + 42$ per cent. In each case practically the same quantity of fiber is obtainable from a given number of seeds, although one variety has a lint percentage of 25 and the other 42. Thus it is seen that the larger percentage of lint is due entirely to a decrease in the weight of the seeds without change in the amount of fiber per seed, a striking illustration of the fallacy of basing an opinion as to the value of a variety of cotton on the percentage of lint alone.

A high percentage of lint, therefore, does not necessarily mean an abundance of fiber. The fiber is actually less abundant when there is 42 per cent of lint in a variety the seeds of which weigh 8 grams per hundred than when there is 30 per cent of lint in a variety the seeds of which weigh 14 grams per hundred.

That the percentage of lint will steadily increase as the size of the seed decreases without altering materially the actual amount of fiber obtainable may be seen if the lint index under a seed weight of $13 + 25$ per cent be taken as a base. Approximately the same lint index may be traced diagonally across the table to the lint index under a seed weight of $6 + 42$ per cent. It can readily be appreciated that this trend represents the possible results of selection based on lint percentages alone.

Conversely, an increase in the weight of the seed may reduce the percentage of lint without reducing the actual amount of lint; but unless the reduction in the percentage of lint is proportionate with the increase in the size of the seed the abundance of the lint is also increased, notwithstanding the reduction of the lint percentage.

This is in accord with the results obtained by Mr. T. H. Kearney in his work in the acclimatization of Egyptian cotton,¹ in which he noted that the lint percentages of his best selections were steadily decreasing from year to year below that of the original imported strain, but on ascertaining the lint indexes of the selections and imported stock he found that there was no actual diminution in the quantity of fiber produced. The decrease in the lint percentage was due entirely to an increase in the weight of the seeds. Mr. Kearney concludes:

The negative correlation between the characters lint percentage and weight of seeds is sufficiently pronounced to indicate that a high percentage of lint is in large measure associated with low weight of seeds. * * * It might be inferred from these facts that lint percentage can be used with greater safety as an index of productiveness in comparing individual plants of a fairly uniform variety than in comparing different varieties.

That the percentage of lint of a selection or variety of cotton should be considered only in the light of the lint index is well illus-

¹ Kearney, T. H. Lint index and lint percentage in cotton breeding. *In* Ann. Rpt. Amer. Breeders' Assn., v. 7/8, p. 25-29. 1912.

trated by comparing the lint indexes given with a seed weight of 8.5 under lint percentages 32 and 42. An increase of 10 in the lint percentage here results in an increase in the lint index or actual quantity of fiber of 4 to 6.15. Practically the same increase in the abundance of fiber would be obtained by increasing the weight of the seeds from 8.5 to 13 grams per hundred, while the percentage of lint remained at 32, or the same result might be secured if the weight of the seeds be increased from 8.5 to 11 grams per hundred and at the same time the percentage of lint be also increased from 32 to 36.

LINT INDEX DETERMINES THE NUMBER OF BOLLS TO THE POUND OF FIBER.

The average Upland cotton boll usually contains eight or nine seeds per lock. Five-locked bolls will therefore contain 40 to 45 seeds per boll. The number of seeds yielding 1 pound of fiber may be found, after the lint index is known, by dividing the number of grams in 1 pound by the weight of the fiber on one seed, or one one-hundredth of the lint index. Roughly, 453 grams equal 1 pound. Therefore, all varieties of cotton that have a lint index of 4 will require 11,235 seeds to produce a pound of fiber. The number of seeds per pound of fiber is constant for every lint index, as indicated by the following formula:

$$453 \div \frac{\text{lint index}}{100} = \text{number of seeds producing 1 pound of fiber.}$$

The lint index, therefore, determines the number of bolls to the pound of fiber.

The number of seeds and of bolls to the pound of fiber computed for different lint indexes is given in Table II.

That the differences in the lint indexes are coincident with the variation in the size of the seeds is shown by the weights of the seeds per hundred as given in the last column, the weights in this case being based on a percentage of lint of 33.

RELATION OF THE LINT INDEX TO THE COST OF PICKING.

The number of seeds that must be harvested so that a pound of fiber may be secured is an item of considerable importance in the cost of picking cotton. An indication of the possible reduction in the cost of harvesting resulting from an increase in the lint index may be had from the following examples, taken from Table II.

If the weight of the seeds be increased from 8.5 to 11.3 grams per hundred with a constant lint percentage of 33, the lint index will have been increased from 4.20 to 5.60, an increase of 1.40 grams of fiber per hundred seeds, or 33½ per cent. This increase in the amount of fiber will have been secured without changing the percentage of lint, and results in reducing the number of seeds required to produce 1

pound of fiber from 10,785 to 8,089. This reduction of 2,696 seeds is equal to 67 bolls of 40 seeds each, or 60 bolls of 45 seeds each, or an average of 64 bolls, which means a saving of 25 per cent in the number of bolls to be picked.

TABLE II.—*Relation of the lint index to the number of seeds and of 5-locked bolls required to produce 1 pound of cotton fiber.*

Lint index	Required to produce 1 pound of fiber.				Average difference in number of bolls for each 10 points in lint index.	Weight of 100 seeds, the lint percentage being 33.
	Number of seeds.	Number of bolls.				
		Bolls of 40 seeds.	Bolls of 45 seeds.	Average.		
4.0.....	11,325	283	251	267	54	<i>Grams.</i> { 8.1 8.5 8.9 9.3 9.7 10.1
4.2.....	10,785	269	239	254		
4.4.....	10,295	257	228	242		
4.6.....	9,847	246	218	232		
4.8.....	9,437	235	209	222		
5.0.....	9,060	226	201	213		
5.2.....	8,711	217	193	205	36	{ 10.5 10.9 11.3 11.8 12.2
5.4.....	8,388	209	186	197		
5.6.....	8,089	202	179	190		
5.8.....	7,810	195	173	184		
6.0.....	7,550	188	167	177		
6.2.....	7,306	182	162	172	25	{ 12.6 13.0 13.4 13.8 14.2
6.4.....	7,078	176	157	166		
6.6.....	6,864	171	152	161		
6.8.....	6,661	166	148	157		
7.0.....	6,472	161	143	152		
7.2.....	6,291	157	139	148	19	{ 14.6 15.0 15.4 15.8 16.2
7.4.....	6,121	153	136	144		
7.6.....	5,960	149	132	140		
7.8.....	5,807	145	129	137		
8.0.....	5,662	141	125	133		
Total reductions due to an increase of 4 grams in weight of 100 seeds...	5,653	142	126	134		

Increasing the lint index from 4 to 5 reduces the number of seeds to be harvested to secure 1 pound of cotton fiber from 11,325 to 9,060, or from 267 bolls to 213 bolls. Expressed in terms of bolls to be picked, this is an average reduction of 54 bolls per pound of fiber. In other words, a variety with a lint index of 4 will run 25.3 per cent more bolls to the pound of fiber than a variety with a lint index of 5. In terms of labor employed, this means that if two men are picking at the same rate or number of bolls per hour, the one picking in a variety having a lint index of 5 will gather the same quantity of fiber in 8 hours that the other, working in a variety with a lint index of 4, will gather in 10 hours.

If a variety having a lint index of 6 be compared with one having a lint index of 4, it will be seen that 90 bolls more, or 50.8 per cent, must be gathered in the smaller seeded variety than in the larger seeded in order to secure a pound of fiber. In the one case the laborer must pick 88,500 bolls, while in the other he must gather some 133,500 bolls to get a bale of lint cotton. We have seen from Table I that the same

lint index may be found in varieties differing greatly in their percentages of lint; in other words, that the lint index is a measure of the abundance of the lint independent of the percentage of lint. Therefore, the number of bolls necessary to be picked to yield a bale of lint remains constant for each lint index regardless of the percentage of lint.

Five-locked bolls to the number of 88,500 will yield a bale of cotton in all varieties having a lint index of 6, and 133,500 five-locked bolls will be required in all varieties having a lint index of 4.

A variety of cotton which has a lint index of 4 and a lint percentage of 33 will have seeds weighing 8.1 grams per hundred, or 12.1 grams per hundred unginned seeds. (Table II.) A variety with a lint index of 5 and the same lint percentage will have seeds weighing 10.1 grams per hundred, or 15.1 grams per hundred unginned seeds. Therefore, if the laborers pick at the rate of 1,500 bolls per hour and the average number of seeds is between 40 and 45 to the boll, 1,500 bolls of the variety with the lint index of 4 will weigh 7,713.7 grams, or 17 pounds and 0.09 ounce. Fifteen hundred bolls of the variety with the lint index of 5 will weigh 9,626.2 grams, or 21 pounds and 3.5 ounces, of seed cotton. Thus, there is a difference of 1,912.5 grams, or 4 pounds and 3.4 ounces, per hour, or 24.8 per cent in favor of the variety with the lint index of 5. In other words, the man picking in the variety with the lint index of 5 will gather the same quantity of cotton fiber in eight hours that the one working in the variety with the lint index of 4 will gather in 10 hours, and if both men work a full 10 hours, picking the same number of bolls per hour, the one in the variety with the lint index of 5 will have 24.8 per cent more pounds of seed cotton at the end of the day than the man working in the variety with the lint index of 4. This may account for the fact that pickers often gather more cotton in a day in one man's field than in another's, and may also suggest a reason for the otherwise unexplainable aversion which pickers have for some fields.

TABLE III.—*Comparison of two varieties of cotton grown in southern Georgia.*

Variety.	Lint.			Comparison of 5-locked bolls.					
	Per centage.	Index.	Length.	Weight of 10 bolls.	Number to the pound.		Number required to yield one 500-pound bale.		Estimated percentage.
					Of seed cotton.	Lint.	Total.	Per plant (at 10,000 plants per acre).	
A.....	36	8.7	<i>Inches.</i> 1 $\frac{3}{8}$	<i>Grams.</i> 109	42	116	58,000	5.5	40 to 45
B.....	41	6.4	$\frac{5}{8}$	72	63	153	79,000	7.5	20 to 25

On a recent visit to southern Georgia the writer was asked to compare two varieties of cotton growing in the neighborhood, for the benefit of the local cotton farmers. Ten 5-locked bolls of each of the two varieties were secured and examined, with the results shown in Table III. Variety B was the local favorite, since it had the higher percentage of lint. In this section of Georgia, although the smaller farmers pick their own cotton, they had not appreciated the disadvantages of the variety they were growing, even from the standpoint of the labor of picking.

INCREASING THE LINT PERCENTAGE DOES NOT ALTER THE COST OF PRODUCTION IF THE LINT INDEX REMAINS CONSTANT.

In the case referred to, in which the same lint index was traced through all percentages of lint from 25 to 42, the labor of harvesting the crop and the efficiency of the laborers themselves are the same in each case. For, since the lint index, which determines the number of bolls to the pound of fiber, is constant, the number of seeds and of bolls producing a pound of fiber also remains constant.

There is another relation of the lint index which has not been worked out as yet, but which may be suggested here as a possibility.

Both Tables I and II show that the higher lint indexes are associated with the heavier seeds. Heavy seeds have a relatively larger percentage of kernels to hulls than smaller or lighter seeds, and the oil content may be found to be associated also with heavier seeds.

IMPROVED METHODS FOR OBTAINING LINT PERCENTAGES.

The usual method of obtaining the percentage of lint in cotton varieties is to weigh a random specimen of the seed cotton and gin it; then reweigh the seed, calculate the percentage of seed, and set down the difference as the percentage of lint. Few workers in cotton selections weigh the lint after ginning and calculate the percentage of lint directly. These operations occasion considerable labor and care in making the various records, and, of course, the more numerous the calculations and entries in the records the greater the liability to error. Owing to these and other considerations it has been found advantageous to begin with a standard sample of seed cotton of 100 grams in weight, a method which avoids the necessity for recording the original weight of the specimen. After this standard sample has been ginned the seeds are weighed. Each gram of seed then represents 1 per cent of the original seed cotton. The difference between the weight of the seed and 100 grams is the weight of the lint removed in ginning and is also the percentage of lint. Thus, this method avoids the necessity for recording the net weight of the seed and of calculating the percentage of lint.

Since this procedure for finding the percentage of lint has been in operation, a balance has been placed on the market equipped for the

direct reading of the lint percentage. The beam is graduated to a maximum of 100 grams. A second graduation is placed on the lower edge of the beam at the right. Reading in the reverse direction, or to the left, this graduation shows the difference between 100 grams

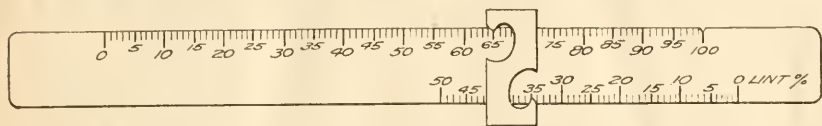


FIG. 1.—Torsion-balance beam, graduated for the direct reading of the lint percentage of cotton.

and the weight indicated, as the rider is moved from the 100-gram mark toward zero. (Fig. 1.) By the use of this balance the percentage of lint, which in this case is the difference between the net weight of the seed and the original weight of the specimen of seed cotton, may be read at a glance without the trouble of subtraction.



FIG. 2.—A balance for the direct reading of the lint percentage of cotton.

Thus, if the seeds of a 100-gram sample of seed cotton are found after ginning to weigh 65 grams, the weight of the lint removed is 35 grams, which is 35 per cent of the original weight of the seed cotton, or the lint percentage. (Fig. 2.)

ADVANTAGES OF USING SAMPLES OF STANDARD WEIGHT.

By the use of a balance such as that just described, the sample is standardized and the work of ascertaining the lint percentage reduced to two entries in the records, the name of the selection and the percentage of lint, and all calculations have been avoided.

The use of the standard sample of seed cotton has other very material advantages. It will be shown that the adoption of the standard sample simplifies the methods of calculating lint indexes and the weights of seeds, that the number of seeds of a standard sample is a direct indication of their size, and that tables may now be prepared by which planters without special apparatus may ascertain the lint index of a variety.

METHODS OF CALCULATING LINT INDEXES AND SEED WEIGHTS.

Having used the standard sample of 100 grams of seed cotton and determined the percentage of lint, which, as has been seen, is the actual weight of the lint, the lint index and the weight of the seeds per hundred may be obtained from the data in hand by the use of the following formulas:

$$\frac{\text{Percentage of lint}}{\text{Number of seeds in specimen}} \times 100 = \text{lint index.}$$

$$\frac{\text{Percentage of seed}}{\text{Number of seeds in specimen}} \times 100 = \text{weight of 100 seeds.}$$

The lint index may also be determined in the following manner. If a sensitive balance is to be had, the weight of 100 fair average seeds fairly ginned should be secured by actual weighing, or, better, the average weight of two lots of 100 seeds should be secured. The following formula may then be used to determine the lint index:

$$\frac{\text{Weight of 100 seeds}}{\text{Percentage of seed}} \times \text{lint percentage} = \text{lint index.}$$

NUMBER OF SEEDS IN A STANDARD SAMPLE AN INDICATION OF THEIR SIZE.

In the absence of a balance sensitive to the hundredth of a gram, on which such small lots of seeds as 100 may be accurately weighed, the use of the standard specimen of seed cotton has another advantage in that the number of seeds in the specimen may be taken as a direct indication of their size, and the weight of the seeds per hundred may be found by reference to Table IV. This table gives a list of the numbers of seeds in standard specimens of 100 grams of seed cotton, calculated for various percentages of lint and weights of seed per hundred.

Having ascertained the weight of the seeds per hundred from Table IV and knowing the percentage of lint, the lint index may then be ascertained by reference to Table I.

TABLE IV.—*Number of seeds in a standard sample of 100 grams of seed cotton at different lint percentages and weights of seed per hundred.*

Weight of 100 ginned seeds.	Percentage of lint.																			
	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42		
Grams.	Seeds	Seeds	Seeds	Seeds	Seeds	Seeds	Seeds	Seeds	Seeds	Seeds	Seeds	Seeds	Seeds	Seeds	Seeds	Seeds	Seeds	Seeds		
6.0	1,250	1,233	1,216	1,200	1,183	1,166	1,150	1,132	1,116	1,100	1,083	1,066	1,050	1,033	1,016	1,000	983	966		
6.5	1,153	1,138	1,123	1,107	1,092	1,076	1,061	1,046	1,030	1,015	1,000	984	969	953	938	923	907	892		
7.0	1,071	1,057	1,042	1,028	1,014	1,000	985	971	957	942	928	914	900	885	871	857	842	828		
7.5	1,000	986	973	960	946	933	920	906	893	880	866	853	840	826	813	800	786	773		
8.0	937	925	912	900	887	875	862	850	837	825	812	800	787	775	762	750	737	725		
8.5	882	870	858	847	835	823	811	800	788	776	764	752	741	729	717	705	694	682		
9.0	833	822	811	800	788	777	766	755	744	733	722	711	700	688	677	666	655	644		
9.5	789	778	768	757	747	736	726	715	705	694	684	673	663	652	642	631	621	610		
10.0	750	740	730	720	710	700	690	680	670	660	650	640	630	620	610	600	590	580		
10.5	714	704	695	685	676	666	657	647	638	628	619	609	600	590	580	571	561	552		
11.0	681	672	663	654	645	636	627	618	609	600	590	581	572	563	554	545	536	527		
11.5	652	643	634	626	617	608	600	591	582	573	565	556	547	539	530	521	513	504		
12.0	625	616	608	600	591	583	575	566	558	550	541	533	525	516	508	500	491	483		
12.5	600	592	584	576	568	560	552	544	536	528	520	512	504	496	488	480	472	464		
13.0	576	569	561	553	546	538	530	523	515	507	500	492	484	476	469	461	453	446		
13.5	555	548	540	533	525	518	511	503	496	488	481	474	466	459	451	444	437	429		
14.0	535	528	521	514	507	500	493	485	478	471	464	457	450	442	435	428	421	414		
14.5	517	510	503	496	489	482	475	468	462	455	448	441	434	427	420	413	406	400		
15.0	500	493	486	480	473	466	460	453	446	440	433	426	420	413	406	400	393	386		
15.5	483	477	470	464	458	451	445	438	432	425	419	412	406	400	393	387	380	374		
16.0	468	462	456	450	443	437	431	425	418	412	406	400	393	387	381	375	368	362		

PLANTERS CAN ESTIMATE THE LINT INDEX.

Since 100 grams equal approximately $3\frac{1}{2}$ ounces, a grower may determine with fair accuracy the size of the seeds of the variety he plants by ascertaining the number of seeds in $3\frac{1}{2}$ ounces of seed cotton and referring to Table IV. He can then estimate the lint index of his variety by a reference to Table I. For example, if a grower finds 566 seeds in $3\frac{1}{2}$ ounces of his seed cotton and his cotton is ginning out 32 per cent of lint, by reference to Table IV the seed will be found to weigh 12 grams per hundred. Referring then to Table I, under a seed weight of $12 + 32$ per cent, the lint index will be found to be 5.64.

SUMMARY.

(1) The percentage of lint is the relation between the weight of the fiber and the weight of the seeds from which the fiber is obtained in the process of ginning and is expressed as a percentage of the un-ginned seed cotton. The use of a lint percentage originated with buyers of seed cotton, and if used by breeders and growers as a measure of the comparative value of varieties it should be employed with

caution, since it is misleading if used except in connection with the lint index.

(2) An increase in the percentage of lint may be due entirely to a reduction in the size of the seed without change in the quantity of fiber.

(3) The lint index is a measure of the abundance of the fiber rather than a measure of the relation between the weight of the fiber and the weight of the seed, as is the percentage of lint.

(4) The lint index determines the number of bolls yielding a pound of fiber. The number of seeds and of bolls required to produce 1 pound of fiber is constant for all varieties of cotton that have the same lint index, regardless of the percentage of lint.

(5) An increase in the lint index is correlated with an increase in the weight of the seeds and reduces the number of bolts required to produce a pound of fiber.

(6) The lint index is an important factor in the cost of cotton production. An increase of a single gram in the weight of the fiber per hundred seeds, without change in the percentage of lint, materially reduces the labor of picking cotton. The efficiency of the pickers also is thereby increased.

(7) It is essential that a planter know the lint index of a variety, as well as the percentage of lint, in choosing a variety to be planted.

(8) Simple methods for ascertaining the lint index, the lint percentage, and the weight of seeds are described, and tables to simplify computation are given.

(9) The importance is shown of using a standard specimen of 100 grams of seed cotton in making determinations of lint percentages, lint indexes, and the weights of seeds.

(10) A method is described by which a planter, without special apparatus, may estimate the lint index and the size of the seed of a variety of cotton by counting the number of seeds in $3\frac{1}{2}$ ounces of seed cotton and referring to the tables in this bulletin.



BULLETIN No. 645

Contribution from the Bureau of Entomology
L. O. HOWARD, Chief



Washington, D. C.

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SOME REASONS FOR SPRAYING TO CONTROL INSECT AND MITE ENEMIES OF CITRUS TREES IN FLORIDA.

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GRADUAL ADOPTION OF SPRAYING.

Among Florida growers there have been developing during late years what may be called two schools for the control of citrus pests. One of these favors dependence upon natural enemies; the other, upon artificial methods, particularly spraying. The relative merits of these two general methods of control are not discussed here, since, as time passes, it becomes more and more evident that there is room for both under the widely varying conditions surrounding Florida groves. Enthusiastic supporters of control by natural agencies such as entomogenous fungi do not believe that the lowering of the grade and the reduction in the size of the fruits and of the yield, if any, are of sufficient importance to demand attention. Or perhaps the case may be stated more fairly by saying that they believe that it is more profitable to use no measures for the control of pests, contending that it pays better to grow the lower grades of fruit without treatment than the better grades with treatment.

It is interesting, however, and very encouraging to note the gradual adoption of a system of spraying for the improvement of orchard conditions by men who, only a few years before the Federal Bureau of Entomology began its demonstration work, believed in, and depended upon, natural agencies as the best all-round method of control. This change has come partly through a realization that fungi

parasitic on certain injurious insects, excellent as they are, have fallen short of what was expected of them, but more as a result of a spraying system developed by the writer, which, by taking all pests into consideration instead of merely the white flies, has proved the direct financial gain that will follow the intelligent application of spray mixtures. It is to certain advantages of this system of spraying that attention is called in this bulletin. Perhaps the best argument in favor of spraying is to be found in the difficulty experienced in securing the same grove for demonstration purposes two or three years in succession. Once the owner has seen with his own eyes the benefits resulting from careful and well-timed spraying, he refuses to accept the losses that he knows will come to him or his company through the setting aside of blocks of trees to serve as checks in community demonstration work.

PESTS OF IMPORTANCE.

Of the total damage caused by insects and mites to citrus in Florida, more than 95 per cent may be attributed to six species. In the order of their destructiveness, these are the citrus white fly,¹ the purple scale,² the rust mite,³ the red scale,⁴ the cloudy-winged white fly,⁵ and the red spider.⁶ There are several other pests of secondary importance, such as the woolly white fly,⁷ the purple mite,⁸ and the chaff scale.⁹ The citrus white fly now infests nearly all the groves in the State. The purple scale is found in greater or less numbers on every citrus tree.

INJURY TO TREES AND FRUIT.

The presence of these pests on the trees and fruit produces blemishes which cause fruit to be placed in a much lower grade than would be the case if these blemishes were not present. While the excellent methods of washing the fruit remove nearly all the sooty mold which follows attacks of the white fly, usually some of it is left near the stem end. When this is present the fruit is placed in a grade lower than if it were absent. The presence of scale insects on the fruit lowers the grade, and, when these are abundant, makes the fruit practically unmarketable unless the scales are removed by hand washing. Perhaps the greatest cause for lowering the grade of fruit is the blemish following rust-mite injury. All these pests devitalize the trees, and this type of injury is much more important than the lowering of the grade of the fruit, because the yield is reduced. This

¹ *Dialeurodes citri* Ashmead.

² *Lepidosaphes beckii* Newman.

³ *Eriophyes oleivorus* Ashmead.

⁴ *Corysophalus aonidum* Linnaeus.

⁵ *Aleyrodes nubifera* Berger, now known as *Dialeurodes citrifolii* Morgan.

⁶ *Tetranychus scirpae* Riley.

⁷ *Aleurothyrus howardi* Quaintance.

⁸ *Tetranychus citri* McGregor.

⁹ *Parlatoria pergandii* Comstock

devitalization is well known and admitted by the citrus growers, but few really appreciate the magnitude of this type of damage. Thousands of trees have been seen so injured by the purple scale that all the inside foliage and small limbs had been killed, and only a mere "shell" of foliage remained. In one small community in 1915 it was estimated that the damage amounted to \$30,000. It cost four times as much to remove the dead wood resulting from insect attack as it would have cost to prevent the damage, and two crops of fruit were lost in addition. At least 75 per cent of the total damage could have been prevented for less than \$2,000. Many citrus growers, realizing that this injury to the trees follows severe scale infestation, apply extra fertilizer so that the trees may have enough nourishment not only for the production of a good crop of fruit, but also to meet the demands made upon their vitality by the feeding scales. The belief is general that more fertilizer is required to get results in a grove heavily infested with scale insects and white flies than in one that is comparatively free from these pests.

To express the extent of this devitalizing effect in a statistical way or on a percentage basis is very difficult. In the two instances given below the damage caused by insect pests and mites is most strikingly shown. Although it is only proper to admit that these two cases represent extreme injury by pests, they indicate that the devitalizing effect which results in diminished yield is much greater, on an average, than most growers have thought possible.

In one instance a row of 16 trees was left unsprayed for three seasons, 1913, 1914, and 1915. The remainder of the grove was sprayed. The citrus white fly was making its first appearance in the grove. During the year 1913 there was little or no difference in the yields of the sprayed trees and the unsprayed check trees. In 1914 the unsprayed row had about 5 boxes of fruit, and the adjoining row of 16 sprayed trees about 60 boxes. All common species of fungi parasitic on the white fly and scale insects were present in great abundance. In 1915 the difference was not so great; the unsprayed row had about 20 boxes of fruit, and the adjoining sprayed row about 50 boxes.

As another instance, in a grapefruit grove at Safety Harbor 84 trees left without treatment during the summer of 1914 averaged two-thirds of a box per tree less than the trees adjoining which were sprayed. The reduction in the yield due to failure to spray was caused by the smaller size of the fruit resulting from rust-mite attack. There seems to be no evidence that the actual number of grapefruit on the unsprayed trees was less than on the sprayed trees.

During the year 1915 the same trees received the same treatment as during 1914. The sprayed trees had at least a good half crop, or about four boxes per tree. The trees adjoining which were left

unsprayed during both years yielded only from one-half to one box per tree. This difference was so marked that all the laborers in the grove noticed it as early as August 1.

THE GRADING OF FRUIT.

PRESENT STATUS.

The percentage of first-grade fruit shipped out of Florida is not as great as it should be. To illustrate this point several tables have been prepared which give the percentages of the various grades shipped. These data have been obtained with difficulty. At first it was thought that information could be obtained from the growers. As a matter of fact the growers, as a class, do not know the percentage of the fruit in the different grades or the price received for the respective grades, for the reason that a large percentage of the citrus crop is sold on the tree, and shipped by those commission firms owning groves.

No information regarding the percentages of the various grades shipped could be obtained from the shipping companies. One important firm wrote that such large quantities of their fruit had been sold at so much per box, regardless of grade and size, that they were unable to give any information about grades and prices. The reports of the New York auction and the Florida Citrus Exchange were available.

The grading of fruit in Florida is in a most chaotic state. Certain grades marked "fancy" bring less money than third or fourth-grade brands. There are no standards for the various grades of fruit; the different grades vary as the season advances, and from year to year. It is very difficult to place each brand of fruit in its proper place. Attempt, however, was made to place it just as the shipper had intended. The Citrus Exchange key to the various brands was followed for all Exchange fruit. Wherever the word "fancy" occurred, this was placed in the first grade, "bright" in the second, and so on. This was strictly adhered to. The following table will explain this more fully:

First grade.	Second grade.	Third grade.	Fourth grade.	Fifth grade.
Fancy.....	Bright.....	Golden.....	Russet.....	Plain.
Stripes No. 1.....	Stripes B.....	Stripes R.....	Stripes Y.....	Big Cypress.
	Blue.....	Red.....	Yellow.....	Plain.
Deerfield F.....	Deerfield B.....	Deerfield G.....		
J. R. W. Fancy....	J. R. W. Choice.....	J. R. W. Golden.....		
	Balls of J.....	Florida Sunshine.....	Apex.....	

In order to arrive at the best estimate of the grades of fruit shipped from Florida at present it seemed best to adopt two fairly distinct methods to determine this for New York City and compare the results with those obtained from other sources.

By the first method the records of fruit sold on four days of each month in New York City were taken into consideration. Usually the days selected were the 3d, 10th, 20th, and 28th or 30th of each month, but other days might have been chosen just as well. The percentages of the various grades of fruit shipped, based upon the records for these representative days, are given in Table 1.

TABLE 1.—*Percentages of various grades of oranges and grapefruit shipped from Florida to New York City during the season of 1915-16.*

Month.	Oranges.					Grapefruit.				
	First grade.	Second grade.	Third grade.	Fourth grade.	Fifth grade.	First grade.	Second grade.	Third grade.	Fourth grade.	Fifth grade.
November.....	8.17	48.55	37.14	5.63	0.5	13.85	55.6	26.61	4.43	0.0
December.....	13.93	43.79	40.18	1.87	.25	20.02	33.68	39.55	6.73	.0
January.....	12.26	38.30	40.89	7.58	.95	9.44	46.72	35.31	8.7	.0
February.....	2.60	32.28	47.07	14.66	2.38	2.58	21.46	48.90	18.77	8.3
March.....	.25	25.89	52.64	17.39	3.81	.6	9.7	50.6	33.4	5.65
April.....	1.16	20.91	50.80	25.51	1.60	.0	17.0	58.57	20.36	4.33
Entire season.	6.68	34.82	45.07	11.80	1.62	6.92	29.86	44.74	15.24	3.25

The data in Table 1 are based upon the sale of 128,487 boxes of oranges and 31,479 boxes of grapefruit. In the second method for determining the percentage of fruit shipped to New York City in the various grades, the fruit was placed in only three grades instead of five. The fruit was classified by the same method used for Table 1, except that fruit marked "fancy" and "No. 1" was placed in the first grade, and all "plain," fourth and fifth grade fruit was left out. The results, based upon a study of the auction sales, including 400,806 boxes of oranges and 126,193 boxes of grapefruit, showed that the percentages of fruit in the three grades were 35.56, 44.33, and 20.10 for oranges, and 34.43, 45.61, and 20 for grapefruit.

These data and those of Table 1 show that the two methods for determining the grades shipped give about the same results. The better grades are shipped during November and December; the poorer grades, toward the close of the season. To a considerable extent this due to the demand of the holiday trade, which calls for the best fruit obtainable. This demand causes such a keen competition among packers that it is difficult for any but the better grades to find a market until after Christmas.

Since the fruit sold in New York City grades much higher than that sold in other markets, and, in fact, better than the average fruit of the State, the percentages of the different grades of fruit of this market and those of other markets must be compared, in order to arrive at a just conclusion as to the amount of fruit in the different grades shipped from the entire State. Such a comparison of grades sold in New York City and other markets, including Baltimore, Boston, Chicago, Cleveland, Philadelphia, Pittsburgh, and St. Louis, is made in Table 2.

TABLE 2.—*Percentages of various grades of oranges and grapefruit shipped from Florida to New York City and other markets during the season of 1915-16.*

Market.	Oranges.				Grapefruit.			
	First grade.	Second grade.	Third grade.	Total boxes.	First grade.	Second grade.	Third grade.	Total boxes.
New York City.....	35.56	44.33	20.10	868,541	34.43	45.61	20.00	272,621
Other markets.....	8.30	44.57	47.13	5,096,817	8.85	36.2	54.9	1,544,929
Totals and weighted percentages.....	12.39	44.53	43.08	5,965,358	12.67	37.62	49.69	1,817,550

Taking into consideration all sources of information regarding oranges and grapefruit shipped out of Florida, the conclusion is reached that for the purpose of this bulletin the percentages of fruit in the first, second, and third grades approximate 13, 41, and 46, respectively.

RAISING THE GRADE OF FRUIT BY SPRAYING.

Since by no means all Florida fruit is graded so well as that shipped to New York, the problem of raising the standard is an important one. Is it worth while? Will it pay? From the results of work in Florida it may be asserted confidently that it is worth while and that it will pay in a very large number of Florida groves. Table 3 gives the percentages of the grades of fruit shipped from the same grove during 1914, 1915, 1916 and during 1917, up to January 15. In 1914 the small amount of spraying done came too late to prevent blemishes caused by rust mites. In 1915 and 1917 the spraying was done at the proper time, but in 1916 the application was made a little too late to produce the best results. The data resulting from this experimental work are so striking that comment is unnecessary.

TABLE 3.—*Result of spraying upon the percentages of grapefruit in the various grades.*

Grade of fruit.	Year and treatment.			
	1914	1915	1916	1917
	Not sprayed.	Well sprayed.	Sprayed too late for best results.	Well sprayed.
First.....	2.7	34.3	15.8	33.7
Second.....	15.8	51.5	51.6	46.3
Third.....	50.0	10.2	17.3	14.2
Fourth.....	31.5	3.7	15.3	5.9

In a second grapefruit grove during the season of 1913-14, when no spraying was done, the percentages of fruit in the four grades ran 0, 13.8, 65.5, and 20.8, respectively. During the season of 1914-15

the fruit from the same trees after having been sprayed ran for the same grades 12.4, 73.1, 14.5 and 0 per cent, respectively. These data, presented by Mr. S. F. Poole before the Florida Horticultural Society,¹ show that spraying raised the percentages of fruit in the first two grades from about 14 to 85.5 per cent, while the same treatment lowered the percentage in the inferior third and fourth grades from 86.37 to 14.5 per cent and raised all fruit above the fourth grade.

In a third grove the grapefruit of the season of 1913-14, which had developed without protection by spraying, gave 0.6, 24, 59, and 16.4 per cent, respectively, in the four grades. The same trees, properly sprayed during 1914, yielded fruits during the 1914-15 season which graded for the same grades 27.4, 67.5, 5, and 0 per cent, respectively. In other words, spraying increased the amount of fruit in the first two grades from 24.6 to 94.9 per cent and reduced that in the lower grades from 75.4 to 5 per cent; increased the first grade from 0.6 to 27.4 per cent and reduced the fourth grade from 16.4 per cent to zero. The fruit in the two groves upon which data have been given were graded by the Winter Haven Citrus Growers' Association, and the spraying was done under the direction of Mr. S. F. Poole, of Winter Haven.

The foregoing data, secured in the same grove two or more years in succession, may raise the question whether the relative abundance of pests, or more favorable climatic conditions, may not have been an important factor in the better crops secured after spraying. Without discussing this point at length the data secured in various groves are given below:

Grove 1.—During 1913, 900 boxes of fruit picked from unsprayed orange trees in the community graded 32.6 per cent "bright" and 67.3 per cent "russet," while 914 boxes picked from a sprayed grove and apparently equally well cared for in other respects graded 90.4 per cent "bright" and 9.5 per cent "russet."

Grove 2.—In the Hill grove at Winter Haven, which was sprayed during 1914, the oranges shipped 60 per cent first, 35 per cent second, and 5 per cent third grade; and the grapefruit, 30 per cent first, 67 per cent second, and 3 per cent third grade. The general run of fruit grown in the same vicinity, upon trees in the same general state of culture except that many had not been sprayed at all and others sprayed only indifferently, and packed by the same packing house, may be taken as a fairly good index to the grade of fruit produced during the same season. This fruit shipped 10 per cent first, 62 per cent second, and 28 per cent third.

Grove 3.—In this grapefruit grove one block of trees was sprayed, a second block was left unsprayed after June, while a third block was kept as a check. Aside from spraying, the trees received practi-

¹ Florida Horticultural Society Report, 1915, pp. 130-132.

cally the same treatment as regards cultivation and fertilization. The fruit in the sprayed and unsprayed blocks grew on trees about 30 feet apart, or in adjoining rows, and was picked and packed on the same day. The carload of sprayed fruit shipped 87.4 per cent first and second and 12.6 per cent third and fourth grades; the unsprayed carload shipped no first, 3.3 per cent second, and 96.6 per cent third and fourth grades. A more striking example of what a maximum infestation of rust mites will do and the benefits derived from spraying can scarcely be conceived. The carload of fruit left unsprayed after June shipped 80.3 per cent first and second and 19.6 per cent third and fourth grades, thus indicating that if rust mites are controlled thoroughly until the 1st of July on grapefruit little damage will result. In other groves russetting has been observed in January and February.

Grove 4.—In this grapefruit grove, 1 mile distant from grove 3, sprayed and unsprayed fruit was grown during 1914 in adjoining rows. The fruit from the sprayed trees shipped 18.8, 58.1, 15.1, and 7.9 per cent, respectively, in the four grades known as "fancy," "bright," "russet," and "plain." The fruits from the unsprayed trees shipped 6.6, 43.6, 49.7 and 6 per cent, respectively, in the same four grades. The percentage of second grade, or "bright," fruit from the unsprayed trees is much greater than from unsprayed trees of grove 3, since the rust mites did not do so much damage in this grove. It will be noticed that 15.1 per cent of the fruit from sprayed trees was russeted, whereas 49.7 per cent was russeted on the unsprayed trees. In grove 4 the poorer results were due to the inefficiency of the spray solution.

The foregoing data, under the general head of grades of fruit, should convince any grower that it is possible to raise the grade of fruit by killing pests so that the fruit will grade at least 35 per cent first, 50 per cent second, and 15 per cent third, instead of the present average for the State, which is 13 per cent first, 41 per cent second, and 46 per cent third. Fruit usually will grow to a remarkable state of perfection on healthy trees if only the insects and mites are controlled. One grove, the fruit of which was packed by an association noted for its high-class work, produced 90 per cent "Blue," or A No. 1 grade. The writer has seen 120,000 boxes of grapefruit from sprayed trees that graded 60 per cent first and 25 per cent second.

REDUCTION IN SIZE CAUSED BY INSECTS.

Insects and mites not only lower the grades of the fruit by the blemishes they cause, but reduce the size to a considerable extent. In raising the grades of the fruit by spraying, large benefits are obtained in preventing the pests from reducing the size. In commercial grading it is very difficult to show the difference in size of

oranges that have been damaged by mites and those that have not, since in commercial houses all large, coarse fruits, as well as more or less fruit that is inferior, are always placed in the second or third grades with the "russets." This reduction in size is so great, however, that even in commercial grading the difference in size in the respective grades is considerable. Thus, in 941 boxes of oranges of the first grade, 7,111 boxes of the second, and 3,376 boxes of the third there were, on an average, 184.2, 197.9, and 200.4 oranges per box; a difference of 7 per cent in the number of fruits per box in the first and second grades, and of 8.8 per cent of those in the first and third grades.

The difference in size of the fruit of the various grades ranges from 4 to 14 per cent. In one community the general run of "bright" fruit (unaffected by mites) averaged 203.8 oranges per box, and the russeted fruit 222.2, or a difference of 9.28 per cent in favor of unaffected fruit. In another near-by grove that was sprayed the "bright" fruit averaged 214 and the "russets" 228 fruits per box, which is a difference of 6.6 per cent.

The number of grapefruit in 360 first, 970 second, and 279 third-grade boxes of fruit averaged 53.2, 57.5, and 51.9, respectively. In this instance the difference in number of fruits per box in the first and second grades is 8.2 per cent. Undoubtedly so many large, coarse fruits were placed in the third grade that these made the average number of fruits per box less than even in the first grade.

It is much better, however, to make comparison of fruit of the same variety from the same grove, and data are given here for this purpose. Table 4 shows the numbers of grapefruit per box for the various grades in a car of sprayed and of unsprayed fruit and of fruit which was not sprayed after June. These are the same carloads of fruit referred to on page 7, grove 3.

TABLE 4.—*Number of grapefruit per box from trees sprayed and unsprayed and from trees unsprayed after June.*

Grade.	Number of grapefruit per box.		
	Sprayed.	Not sprayed after June.	Not sprayed.
1. Fancy.....	42.2	46.6	0.0
2. Bright.....	43.6	49.7	48.4
3. Russet.....	45.2	52.3	49.3
4. Plain.....	38.8	43.2	46.1
General average.....	42.8	49.0	49.1

It will be seen that the sprayed fruit averaged 42.8 and the unsprayed fruit 49.1 fruits per box. This difference may not appear to be very great at first sight, but if the unsprayed fruit had been as

large as the sprayed, there would have been 344.1 boxes of fruit instead of 300, or a gain of 14.7 per cent. The "russet" grade is smaller in all cars than either the "fancy" or "bright." All large, coarse fruits, were packed in the "plain," although they might be classed as "brights." Table 4, although it contains the data given by a commercial concern, does not indicate as great a difference as really existed. On the unsprayed trees there were many fruits so small and of such poor quality that they were never sent through the packing house.

Grapefruit grown about 1 mile from that discussed in Table 4 was sprayed with a different material, soda-sulphur. The sprayed and unsprayed fruit was picked on the same day. The number of fruits per box from the sprayed trees averaged, for the same grades given in Table 4, 47.8, 51.7, 56, and 53.4 per box, respectively; from the unsprayed trees, 52.3, 56.7, 59.5, and 0, respectively. The "russet" fruit in both cases was much smaller than any of the other grades. Taken as a whole, the fruit from the sprayed and unsprayed trees averaged 51.5 and 57.8 fruits per box, respectively, which gives a percentage difference of 12.3 in the number of fruits in favor of spraying. In another instance grapefruit from sprayed trees averaged 50.2 fruits per box as compared with 57.8 fruits from unsprayed trees in adjoining rows; a difference of 15.2 per cent in favor of sprayed fruits.

The reduction in size following rust-mite attack accounts, to a certain extent, for the small number of boxes produced in 1911, when practically all the unsprayed citrus fruit was "russet," and about half was "black russet," or about two sizes smaller than it would have been had it not been affected by rust mites. One test shows that 66 sprayed fruits filled the same box as 99 unsprayed fruits picked from an adjoining row, or a difference of $33\frac{1}{3}$ per cent. From orange trees sprayed with lime-sulphur, 1-25, April 22, 1911, 338 fruits averaged 3.29 inches in diameter. The skin of this fruit was smooth and the texture good. From unsprayed adjoining orange trees 1,234 fruits averaged 2.58 inches. It would require 112 of the former to fill the average orange box and 226 of the latter, or twice as many.

The reduction in size is also shown by the average weight of the fruit. In a miscellaneous lot of oranges, graded commercially, 575 "brights" weighed 241 pounds and 575 "russets" weighed 225 $\frac{1}{2}$ pounds, which made a difference of $6\frac{1}{3}$ per cent. This fruit, of course, had been picked at the same time and from the same grove and the collection represented all the different sizes. The fruit had not received any spraying. In another lot, 75 "bright" grapefruit which had been sprayed thoroughly throughout the season weighed 99.75 pounds, and 75 fruits which had received no spraying throughout the year weighed 88 pounds, which makes a difference of 11.77 per cent.

The foregoing data show that the loss resulting from the reduction in size of the fruit is close to 12.5 per cent, or about one size. About half the citrus crop of Florida suffers this loss. The data also confirm the observations made on the size of "brights" and "russets" when packed. When fruit is graded in a packing house and then run through the sizer the full bin on the "bright" side is invariably one size larger than the full bin on the "russet" side. These facts also substantiate the statement of Mr. S. O. Chase, of Sanford, Fla., who figured out more than 25 years ago that the increase in size which results from spraying pays for the cost of spraying. They also confirm the statements of Mr. F. D. Waite, of Palmetto, and Mr. A. B. Harrington, of Winter Haven, that rust mites reduce the size about $12\frac{1}{2}$ per cent.

The belief is general in Florida that "russet" fruit will ship better, or with less decay, than "bright" fruit. If this is the case it is possible that the supposedly superior shipping qualities of the "russet" fruit might outweigh any advantages which the "bright" fruit might possess. While the data given in the following paragraphs may not be entirely conclusive, they certainly show that bright fruit, which retains its natural "waxy" coating for protection, ships equally as well or better than "russet" fruit, or fruit that has been injured by rust mites to the extent of losing its normal protection.

Test 1: Grapefruit—On January 30, 24 brights and 24 russets were picked and placed in the laboratory. These were examined from time to time, and on April 7 $46\frac{2}{3}$ per cent of the bright fruit had decayed and $58\frac{1}{3}$ per cent of the russets.

Test 2: Fifty-one grapefruit each, of brights and russets, were picked on the same day as the preceding and placed in the laboratory. On April 7, 49 per cent of the brights had decayed and $75\frac{1}{2}$ per cent of the russets.

Test 3: Oranges—One box of bright oranges and one box of russet oranges, each containing 200 fruits, were purchased at the packing house on March 9. These fruits were picked from the same grove. On April 7 the bright oranges showed $48\frac{1}{2}$ per cent decay and the russet oranges 59 per cent.

Test 4: One box of brights and one box of russets containing 160 oranges each were set aside March 9. On April 7, 29.3 per cent of the bright fruit had rotted and 30.6 per cent of the russets.

Test 5: One box each of brights and russets, containing 150 oranges each, were used on March 3. On April 7, 56 per cent of the bright fruit had decayed and 66 per cent of the russet.

Test 6: One-half box each of brights and russets were put under observation on March 3. On April 7, 54 per cent of the brights had rotted and 74 per cent of the russets.

In the spring of 1917 another series of experiments was conducted to determine the relative merits of bright and russet fruit with reference to their carrying qualities. Twelve lots of oranges, each containing an equal number of brights and russets, were picked and carefully selected so as to avoid any mechanical injuries. So far as possible, the brights and russets from each lot were taken from the same tree. Examinations were usually made every seven days. Table 5 gives the percentage of decay for each period of all the lots.

TABLE 5.—Percentage of decay of "brights" and "russets."

Number of days.	"Brights."				"Russets."			
	Number of sound fruits.	Number of decayed fruits.	Total number of decayed fruits.	Per cent decay.	Number of sound fruits.	Number of decayed fruits.	Total number of decayed fruits.	Per cent decay.
	95	0	0	0.0	95	0	0	0.0
5	94	1	1	1.05	95	0	0	.0
12	93	1	2	2.10	95	0	0	.0
19	89	4	6	6.31	87	8	8	8.42
26	79	10	16	16.84	78	9	17	17.90
33	71	8	24	25.26	56	22	39	41.05
40	60	11	35	36.8	40	16	55	57.90
47	59	1	36	37.89	31	9	64	67.36
54	50	9	45	47.36	12	19	83	87.36
61	34	4	49	51.57	11	1	84	88.42

The above experiment was terminated about 2½ months after it was started. At that time 27 of the bright fruits were sound, 25 of which were eaten, and only 3 of the russets were sound, none of which were edible. The 95 bright fruits had averaged 51 days and the 95 russet had averaged 36 days before developing decay. In 11 of the 12 lots the brights lasted longer than the russets. According to weight, the percentage of decay was 45.3 in the brights and 64.8 in the russets.

The rate of evaporation of the juices is also much greater in russet fruit than in bright. From January 30 to April 7, 1915, 24 bright grapefruit lost 4.7 per cent and 24 russet lost 13.6 per cent from evaporation. During the same time 51 bright grapefruit lost 5.9 per cent, and the 51 russet lost 9.5 per cent. One box of bright oranges lost 10.4 per cent, and another box of russets containing the same number of fruits lost 15 per cent. Another box of brights lost 14.8 per cent by evaporation and the box of russets lost 17.9 per cent. In one box of half brights and half russets the brights lost 17.4 per cent and the russets 21 per cent. In one box of brights the loss from evaporation was the same as that sustained by the russet box. In 8 of the 12 lots mentioned under "decay" (Table 5) the percentage of evaporation was greater from russet than from bright fruit and the total of the 12 lots showed the russets evaporated 23.12 per cent and the bright 22.68 per cent.

There seems to be an impression among consumers and retail dealers that russet fruit is a variety of citrus instead of being the result of the former presence of thousands of rust mites. The responsibility for this erroneous idea rests with the salesman. It is considered good salesmanship to sell what goods there are on hand and to convince the purchaser of the merits of the same. Since more than half the crop is russet, some explanation must be made to the consumer as to the quality of the fruit he purchases. The explanation that russet fruit is a variety fulfills all the requirements of good salesmanship. The necessity for this exercise of shrewd salesmanship, as well as its continuation, rests with the Florida citrus grower.

One also hears frequently in Florida that russet fruit is sweeter than bright. So far as is known, no analyses indicate that such is the case. Since the russet fruit is not sold before the holidays, it has ample opportunity fully to ripen, so no russet fruit is ever sour. In some tests made March 25, 1914, several russet and bright oranges were peeled so that they could not be told apart by the taster. These were given to a person to taste. In both cases where bright and russet fruit were compared, the person pronounced that the bright was the sweeter. On January 29, 1915, five men pronounced sprayed fruit sweeter and possessed of a greater refinement and delicacy of flavor than unsprayed fruit from adjoining rows.

BETTER GRADES OF FRUIT BRING BETTER PRICES.

Obviously it is useless to raise the grade of fruit if second and third grade fruit sell for as much as the first grade. There is no reason to spend money to make first-grade fruit unless the improved fruit brings a good yield on the investment required to produce it.

In order to show the difference in price received for different grades of fruit Tables 6 and 7 have been prepared. The data of Table 6 are based upon the returns from the 128,487 boxes of oranges and the 31,479 boxes of grapefruit, and these data are given in Table 1.

TABLE 6.—*Difference in the price received in the New York market for different grades of oranges and grapefruit during the season of 1915-16.*

Month.	Difference in price received between the grades of—									
	Oranges.					Grapefruit.				
	First and second grade.	Second and third grade.	Third and fourth grade.	Fourth and fifth grade.	Total difference.	First and second grade.	Second and third grade.	Third and fourth grade.	Fourth and fifth grade.	Total difference.
November.....	\$0.39	\$0.28	—\$0.01	\$0.39	\$1.06	\$0.66	\$0.36	\$0.29	\$0.00	\$1.30
December.....	.57	.08	.09	.05	.79	.55	.57	.26	.00	1.36
January.....	.23	.14	— .00	.37	.74	.37	.36	.34	.00	1.08
February.....	.73	.14	.14	.37	1.38	.68	.25	.25	.03	1.21
March.....	1.36	— .09	— .16	.49	1.59	2.22	.43	.47	.29	11.20
April.....	.96	.14	.06	.67	1.82	.00	.18	.17	.25	.60

¹ Difference between second and fifth grades; first grade is unusual sale.

The dash (—) placed before the difference in price indicates that a lower grade sold for more than the next higher grade. This occurred several times among the grades of oranges, but not among those of grapefruit. The only explanation that can be offered for this irregularity is that the lower grades had the sizes desired by the trade at the particular time of the sale.

Table 7 shows the differences in price for the grades of 400,805 boxes of oranges and 126,193 boxes of grapefruit when these are divided into three instead of five grades.

TABLE 7.—*Differences in the price received in the New York market for different grades of oranges and grapefruit during the season of 1915-16.*

Month.	Difference in price received between the grades of—					
	Oranges.			Grapefruit.		
	First and second grades.	Second and third grades.	First and third grades.	First and second grades.	Second and third grades.	First and third grades.
November.....	\$0.342	\$0.044	\$0.385	\$0.517	\$0.314	\$0.831
December.....	.243	.136	.379	.369	.654	1.023
January.....	.221	.117	.338	.237	.362	.599
February.....	.168	.114	.282	.378	.325	.703
March.....	.099	.054	.045	.295	.569	.864
April.....	.226	.110	.336	.059	.279	.338

If the difference in price received for the first and third grades be added and the sum be divided by the number of months, an average difference of 30 cents in price received for the oranges and 72 cents for the grapefruit is obtained. In a miscellaneous lot of 5,427 boxes of fruit, the first grade averaged 48.8 cents more than did the second grade, and the second averaged 8.3 cents more than did the third grade.

Opportunity is seldom presented for comparing the price of sprayed and unsprayed fruit from the same grove. Through the cooperation of Mr. J. A. Stevens, of De Land, this was done with two carloads of grapefruit shipped in 1914 from sprayed and unsprayed trees, that were picked and packed on the same day and sold in the same market. The sprayed fruit sold for \$1.94 per box; the unsprayed fruit for \$1.69. These respective prices are disappointing. It had been anticipated that there would be at least a difference of 75 cents instead of 25 cents in favor of the sprayed fruit. The net profits due to spraying, however, were sufficient to pay one-fourth of the freight charges. Although the difference is slight, it is more than four times what it cost to spray the trees. The prices of the respective grades of the fruit could not be obtained.

In a grove about 1 mile distant from the grove previously mentioned 516 and 300 boxes of grapefruit, respectively, were picked from

sprayed and unsprayed trees in adjoining rows. It is not known whether all the fruit was sold in the same market. The sprayed fruit brought 98 cents per box, the unsprayed fruit 85 cents per box. The difference in price, though small, was twice the cost of spraying. Because of the vagaries of the market, due to the daily fluctuation in supply and demand, it can not be stated that the better grades will always bring the better price, yet the data presented leave no doubt that spraying raises the grade of the fruit and largely overcomes the devitalized effect caused by insects, and that, other things being equal, the better grades bring better prices.

SPRAYING SCHEME FOR CONTROLLING CITRUS PESTS.

As a general proposition the time to spray for the control of all pests of citrus trees is when they are present in such numbers that, if left to reproduce without artificial hindrance, they would soon become injurious. In other words the pests should be killed before they can do much damage to either the tree or the fruit. The pests should always be kept in such a state of repression that they can do little or no damage. In case the various pests of citrus are permitted to become so abundant as to cause injury, the profits which may be expected from artificial treatment, such as spraying with an insecticide, are, to a certain extent, lost. Fortunately the life history and habits of nearly all citrus pests are such that good results can be obtained at any time of the year when the spray is applied. Nevertheless there are times when spraying is more opportune than at others. These periods come when the largest number of the insects are very young, for then they are killed most easily.

The following spray scheme has been used very extensively for four summers in Florida and generally has given satisfactory results. It must be admitted, however, that no hard and fast scheme can be recommended, and that to a large extent the number of sprayings depends on the thoroughness of the work.

I. *Paraffin-oil emulsion; Government formula, 1-66 or 1 per cent of oil.* May.—The main object of spraying at this time is to kill white flies, scale insects, and, to a large extent, rust mites. This treatment, however, must not be relied upon to control rust mites. The spraying should be done after the adults of the first brood of white flies have disappeared and before the appearance of those of the second brood. The fruit should be an inch or more in diameter. Since this treatment is given before the beginning of the rainy season, it does not interfere with the work of the beneficial fungi in reducing those insects not killed by the spray.

II. *Lime-sulphur solution, 32° Baumé, 1-50 to 1-75.* June to July.—The main object of this treatment is to kill rust mites, and the

correct time for its application varies with the appearance of the maximum number of the rust mites. It should be applied before the mites get very abundant and before any russetting appears. It will also kill some scales and white flies, but is not of great value for that purpose.

III. *Paraffin-oil emulsion; Government formula 1-66, or 1 per cent of oil. August 25 to October 31.*—This is the second spraying for white flies and scale insects. The object of spraying at this time is to kill the white-fly larvæ which are the progeny of the third and last brood. It is this brood that causes nearly all the damage from the white flies, and the earlier they are killed the better it is for the trees. This spraying also will remove the sooty mold from the trees and a sufficient amount from the fruit to permit the fruit to be colored up by the sun. *Soda-sulphur, 1-50*, may be added to this spraying to increase its effectiveness in killing rust mites.

IV. *Lime-sulphur solution, 32° Baumé, 1-50 to 1-75. November or December.*—The object of this spraying is to kill rust mites, and it may or may not be necessary, depending on the abundance of the mites.

It may be necessary to spray for rust mites before Treatment I is given. This is especially the case with grapefruit in the more southern counties. In case the red spider becomes abundant enough to cause injury, an application of lime-sulphur solution should be given. In case of heavy scale-insect infestation it may be necessary to spray three times with the oil sprays, in which case the treatment can be given in midsummer or in winter. If the red scale is very abundant, two sprayings with the oil emulsions should be given at intervals of about a month.

The paraffin-oil emulsion may be made according to directions given in Circular No. 168, Bureau of Entomology.

In addition to the foregoing there are three highly satisfactory miscible-oil sprays on the market in Florida.

The soda-sulphur solution is made according to the standard formula: 30 pounds of sulphur, 20 pounds of caustic soda, and 20 gallons of water. This tests about 16° Baumé and may be used 1-40 instead of lime-sulphur solution, but it is not so effective in controlling rust mites. It has an advantage over lime-sulphur solution in that it mixes readily with the oil emulsions.¹

COST OF SPRAYING.

The cost of spraying depends upon many different factors, such as the size of the trees, nearness to water, convenience of operation, type of spraying outfit employed, insecticide used, and character of

¹For directions for making lime-sulphur solution see Farmers' Bulletin 908.

the labor. No grower should expect to spray a bearing tree for less than 3 cents for each application. It would be better to place the minimum at 4 cents. It should not require more than 10 cents to spray the largest trees in the State if any considerable number are present in one grove. An average cost per tree should not exceed 5 to 6 cents. If one figures the cost per box, a minimum would be 1 cent per application for oil spray and somewhat less for lime-sulphur. A maximum would be $1\frac{1}{2}$ cents for either insecticide. An expenditure of more than 6 cents per box for the entire year should be unnecessary.

PROFITS AND BENEFITS.

It is impossible to express accurately the percentage of profit to be expected from spraying to control pests on citrus. The same condition applies to cultural and other grove operations in Florida. The data at hand are sufficiently accurate, however, to be worth presenting.

It has been shown that the better grades bring more money than the lower, yet it would be fallacious to assume that if the entire crop were of a high grade the grower would receive correspondingly higher prices. The trade will consume only so much high-grade fruit. It is reasonably certain, however, that the Florida crop has not yet reached the high standard where it would be no longer profitable to produce more high-grade fruit.

At present 13 per cent first, 41 per cent second, and 46 per cent third grade oranges are shipped from the State, and it is possible and practicable to raise this standard to 35, 50, and 15 per cent for first, second, and third grades, respectively. It is assumed that the trade would handle fruit of this quality. Thus, the first grade is increased 22 per cent and the second 9 per cent. If 7,600,000 boxes are taken as the basis for the crop of 1915-16, there would be 1,273,987 boxes more in the first grade if spraying were done. These would sell, according to Table 7 (oranges) for 21.6 cents¹ more per box, or an increase of \$275,181. There would also be 9 per cent more second grade, or 521,177 boxes. These would sell for 9.6 cents more, or an increase of \$50,033.

The percentage of the various grades of grapefruit was not very different from that of the oranges, so 13, 41, and 46 per cent may be used to represent the first, second, and third grades of grapefruit, respectively. The standard for grapefruit also can be raised to grade 35, 50, and 15 per cent. There would then be 22 per cent, or 399,685 boxes, which would sell for 30.9 cents per box more, an increase of \$123,559. There would be 9 per cent, or 163,508 boxes, which would

¹ New York City prices. Other prices could not be obtained.

sell, according to Table 7 (grapefruit), for 41.7 cents more per box, or an increase of \$61,182.

The total increase in value by raising the grade would be \$509,955 for the entire crop of oranges and grapefruit.

Elsewhere in this bulletin it has been shown that "russet" fruit is of about one size, or about 12.5 per cent smaller than normal fruit. If it is estimated that one-half of the crop is "russet" there would be a reduction of 475,000 boxes, which, valued at \$1, would produce a loss of \$475,000. This is extremely conservative. As a matter of fact, 100,000 boxes of fruit in Florida are thrown away because the fruit is too small!

In regard to the reduction in yield caused by the devitalization of the trees, it is very conservative to estimate this at 10 per cent, or 760,000 boxes. In reality it is probably 20 to 25 per cent, and many sprayed groves prove this to be true, but for this estimate it is placed at 10 per cent. This amount of fruit is valued at \$760,000.

This would make a total of \$1,744,955 as a minimum estimate for the increase that could be expected from spraying the entire crop. The cost of spraying groves producing 7,600,000 boxes would be not more than 6 cents per box, or \$456,000. This would be a net gain of \$1,288,955 in the value of the crop produced. This gain could be divided in half and still a handsome profit would follow spraying.

In addition to the direct profit, there is the satisfaction, which every enthusiastic orange grower must feel, in maintaining healthy trees and producing high-grade fruit.

CONCLUSION.

Of the total damage caused by insects and mites to citrus in Florida, more than 95 per cent may be attributed to six species. These, in the order of their destructiveness, are the citrus white fly, the purple scale, the rust mite, the red scale, the cloudy-winged white fly, and the red spider.

Aside from the satisfaction of growing fine fruit and owning healthy trees, it is estimated from the data reported in this bulletin that had the 1915-16 crop of oranges and grapefruit been sprayed according to the schedule recommended, the growers of Florida would have increased their net returns by \$1,288,955.

There is no reason why the standard percentage of fruit in the higher grades can not be raised so that the percentage in the first, second, and third grades will be 35, 50, and 15 instead of, as at present, 13, 41, and 46. In one of several instances given, spraying increased the amount of fruit in the first and second grades from 24.6 to 94.9 per cent, and reduced that in the third and fourth from 75.4

to 5 per cent; increased the amount in the first grade from 0.6 to 27.4 per cent, and reduced that in the fourth from 16.4 per cent to zero.

The better prices which, in most instances, can be obtained for the better grades of fruit fully warrant the adoption of a spray system that improves the grade and the amount of fruit produced. The data presented leave no doubt as to the practicability of making such improvement in the Florida citrus crop if the grower will adhere to the spray schedule outlined.

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PROFESSIONAL PAPER

April 8, 1918

LESSONS ON PORK PRODUCTION FOR ELEMENTARY RURAL SCHOOLS.¹

By E. A. MILLER, *Specialist in Agricultural Education.*

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INTRODUCTION.

Importance.—The growing of hogs is recognized as one of the most important phases of the live-stock industry. The value of hogs as meat-producing animals is attested by the facts that they are grown on 70 per cent of farms and that they constitute so large a part of the number of all farm animals. The United States Department of Agriculture Crop Report gives the following interesting figures with reference to the number of each kind of the leading farm animals in our country on January 1, 1917: Hogs, 67,453,000; sheep, 48,483,000; milch cows, 22,768,000; other cattle, 40,819,000; horses and mules, 25,765,000.

Educational value.—The great importance of the subject as indicated in the previous paragraph and the readiness with which it lends itself to the teaching of the principles of breeding, feeding, and management of farm animals give it unusual educational value. The application of these principles in connection with hogs may be studied and observed in the brief period of one year. Its educational value is recognized by school officials and extension workers and it is being made use of as a home project and as a phase of club work.

It is with a view to introducing into the schools in a definite way the study of this important phase of animal husbandry that the fol-

¹ Prepared under the direction of C. H. Lane, Chief Specialist in Agricultural Education.

NOTE.—This bulletin is intended for the use of teachers of elementary agriculture.

lowing lessons are outlined. Each lesson topic affords ample material for one or more recitation periods.

Practical exercises.—The principles set forth in these lessons should be given practical application by the pupils in the growing of pigs at home. Such practice is usually denominated “home project” work. Suggestions in this connection under the heading “Practical exercises,” are given with each lesson. Each member of the class should have charge of one or more pigs or assume responsibility for the care of hogs at home.

References.—The publications referred to may be had from the United States Department of Agriculture, Washington, D. C., so long as available. Teachers and pupils should write to the State college of agriculture for publications on the subject. All reference material possible should be secured at the beginning of the year.

Correlations.—Some suggestions are made in connection with each lesson topic as to the utilization of this subject in vitalizing the other subjects in the school curriculum. These correlation suggestions are not intended as a part of the lesson in connection with which they appear, but should be used with recitations in the other subjects. Teachers in rural schools should take advantage of every opportunity to give purpose to school instruction by connecting it with the problems at the homes of the pupils.

NOTE TO THE TEACHER.—To make most effective the teaching of the lesson topics found in this publication the following points should be kept in mind and observed: (1) A monthly or seasonal sequence plan should be followed in the presentation of topics; (2) simple classroom exercises such as the working out of feeding rations should be performed; and (3) members of the class should carry on home work with pigs for profit. To have real educational value this home work should meet the following requirements: (a) The work with pigs should be a part of the regular instruction in agriculture; (b) a definite plan should be followed in raising, feeding, and managing pigs; (c) the parents of pupils should agree to and approve the home work of pupils; (d) the home work should be carefully supervised by some competent person; and (e) detailed records of labor, methods, expenditures, and incomes should be kept and reported upon in writing by the pupil.

LESSON I.

TOPIC: TYPES AND BREEDS.

Time.—Early fall.

Lesson outline.—There are two types of swine, namely, the fat or lard type, and the bacon type. Both types are found to a greater or less extent in most parts of the country and are the outcome of local conditions rather than market requirements. The lard type prevails in sections where corn is used as the principal feed, and the bacon type is generally found on farms where corn is scarce and market conditions warrant the production of this type of hog.

The lard type (fig. 1) of hogs is one which has a compact, thick, deep, smooth body and is capable of fattening rapidly and maturing early.

The hams, back, and shoulders are the most valuable parts and should be developed to the greatest possible extent. The whole body of the animal should be covered with a thick layer of flesh representing the extreme development of meat production. This type of hog, under good conditions, should weigh 200 pounds or more when 7 to 9 months of age. This is the most popular market weight. Due to the facts that corn is the most abundant hog feed and lard hogs mature very early, this type predominates.

The most popular breeds of the lard type are the Berkshire, the Poland-China, the Duroc-Jersey, the Chester White, and the Hampshire.

The Berkshire had its origin in England and takes its name from a shire or county by that name. The color is black with white mark-

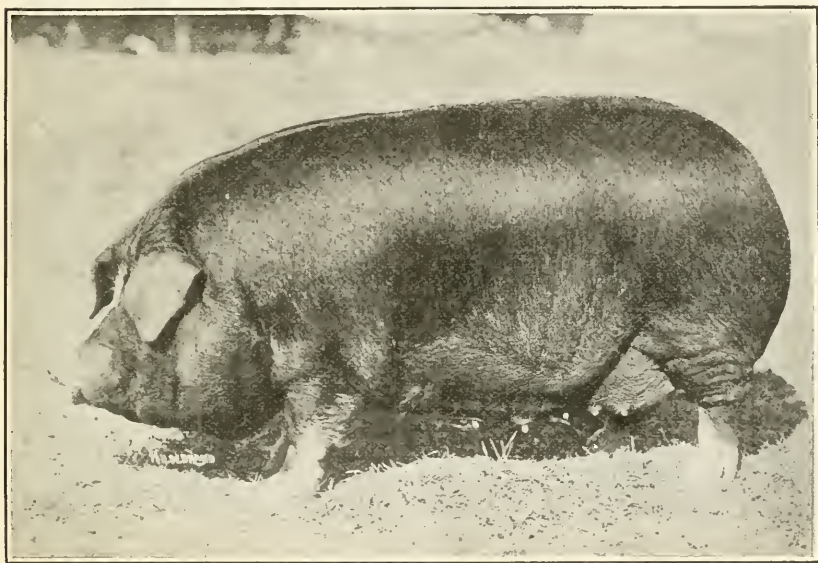


Fig.1.—The lard type.

ings in the face, on the feet, and on the tip of the tail. The face is moderately dished and the snout is of medium length. The ears are usually erect, though they may incline forward in aged animals.

The Poland-China originated in Butler and Warren Counties, Ohio. The breed takes its name from the two breeds from the crossing of which it is supposed to have resulted, namely, a Poland breed and a Chinese breed. The color is black with white on feet, face, and tail. The face is nearly straight and the jowl is full and heavy. The ears should be firmly attached with the tip drooped.

The Duroc-Jersey had its origin in the blending of two red breeds, the Jersey Reds of New Jersey and the Durocs of New York. The color is cherry or yellowish red. The face is slightly dished, the snout is of medium length, and the ear is drooped.

The original Chester White had its origin in Chester County, Pa., hence the name. There are two other strains known as the Improved Chester White or Todd's Improved Chester White, and the Ohio Improved Chester White, commonly known as the OIC strain. The color is white. The face is straight; the snout is usually longer than that of the Poland-China. The ear is drooped. In general conformation the Chester White and Poland-China are very much alike.

The Hampshire breed was formerly known by the name of Thin Rind. The breed seems to have had its origin in Hampshire, England. The color is black with a white belt 4 to 12 inches wide encircling the

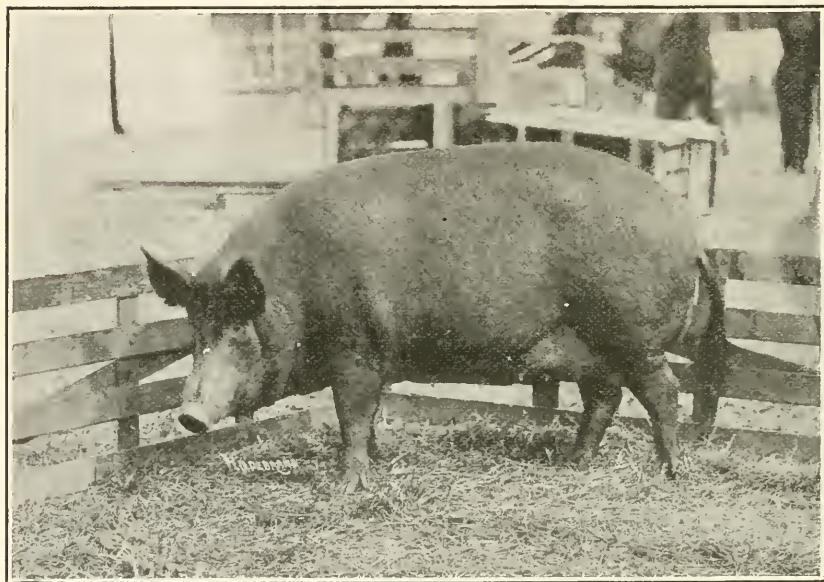


FIG. 2.—The bacon type.

body and including the forelegs. The face is straight and the ear inclines forward but does not droop.

The bacon type (fig. 2) differs from the lard type in that the animals are more active, have longer legs and stronger bones, and do not carry as much fat as the latter. Their bodies are longer than those of the lard hogs. The hams and shoulders are light but the bodies are deep and wide. The most popular market weight ranges from 175 to 200 pounds.

The most common breeds of this type are the Tamworth and the Yorkshire.

The Tamworth is of English origin and takes its name from Tamworth in Staffordshire. The color varies from a golden red to a chestnut shade. The face is practically straight, the snout is long and straight, and the ear is inclined slightly forward.

The large Yorkshire breed originated in England and takes the name of the shire of that name. The color is white. The face is slightly dished and the snout is of medium length. The ears are large and erect, but may incline forward in old animals.

Study questions.—Name the types of hogs. Give the distinguishing points of each type. Name the leading breeds of each type. Briefly describe each breed. What other breeds are found in the community? Describe each. To which type does each belong? For what purposes are hogs grown in the community? Home meat supply? Market?

References.—Farmers' Bulletin 765.

Practical exercises.—Make a hog survey of the community, using the accompanying table for tabulating the facts collected.

COMMUNITY HOG SURVEY.

Name of pupil..... Date.....

	Males.		Sows.		Small pigs.		Large pigs.		Total.		Notes.
	Num- ber.	Value.	Num- ber.	Value.	Num- ber.	Value.	Num- ber.	Value.	Num- ber.	Value.	
<i>Pure bred.</i>											
Berkshire.....											
Poland-China.....											
Duroc-Jersey.....											
Chester White.....											
Tamworth.....											
Yorkshire.....											
Hampshire.....											
<i>Grads.</i>											
Berkshire.....											
Poland-China.....											
Duroc-Jersey.....											
Chester White.....											
Tamworth.....											
Yorkshire.....											
Hampshire.....											
Scrub.....											
Grand total.....											

Correlations.—Few people know how to make tabulations of facts or to interpret statistical tables made by others. Exercises of this kind can be made a most important part of the written work of the pupils. Such work is provided in the foregoing "practical exercise." In addition to written work, facts are provided by such a tabulation for exercises in arithmetic adapted to the advancement of the pupils.

Compare the geographical conditions of the community with those sections in which various breeds of hogs originated.

Require the pupils to make sketches of the different breeds of hogs found in the community, placing special emphasis upon the characteristic features of each breed.

LESSON II.

TOPIC: HOUSES.

Time.—Early fall.

Lesson outline.—Location: A well-drained site should be selected and, if possible, should have sufficient elevation to give the hogs a climb in reaching it. If practicable the house should occupy the south side of a hill.

Principles of construction: Four important things should be observed in hog-house construction; namely, light, ventilation, warmth, and cleanliness. Light is provided by placing the house along a north and south line and by putting in suitable doors and

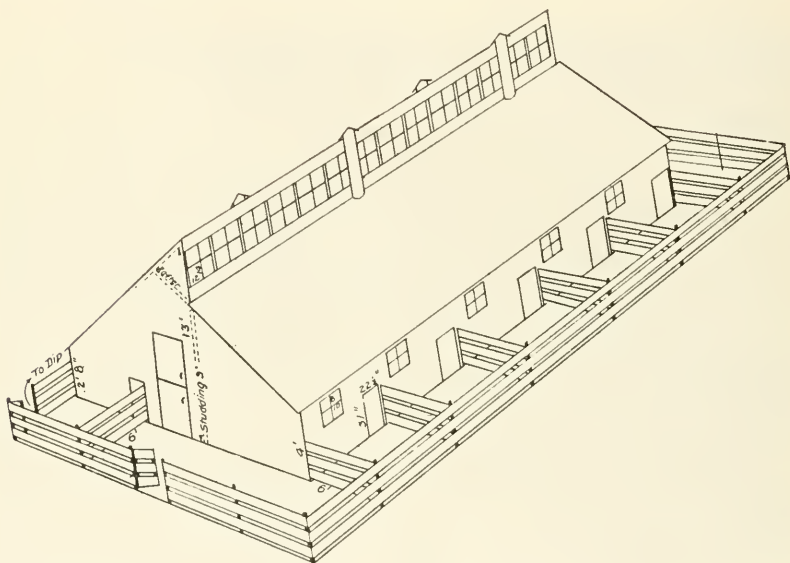


FIG. 3.—Large or community house.

windows. Doors, windows, and roof ventilation furnish a proper interchange of air. Hogs need good ventilation as well as people. A well-constructed house with good floor and bedding provides sufficient warmth.

Let it be remembered that the hog has little natural protection from cold; hence the necessity for comfortable quarters. Cement makes a satisfactory floor, but in colder climates must be covered with wooden false floors. A good floor makes it much easier to keep the house clean. The arrangement of the house should be such that the beds and feed floors are well separated.

Kinds of houses: There are two general classes of houses—large community or stationary (fig. 3), and small individual or movable (fig. 4). The large house has individual pens and is intended for

quite a number of hogs. The advantages of the large house are: It is more economical for a large number of hogs; it is convenient for feeding and affords provisions for saving manure. If the house is to be quite large it is usually advisable to arrange the pens in two rows with an alley way between. The alley should be 4 to 6 feet wide unless it is desirable to have space for the passing of a wagon. In that event the alley should be 8 to 10 feet wide.

The individual house, as the name suggests, is intended for one hog or for a sow and her brood. One decided advantage of the individual or portable house is that it can be moved from place to place

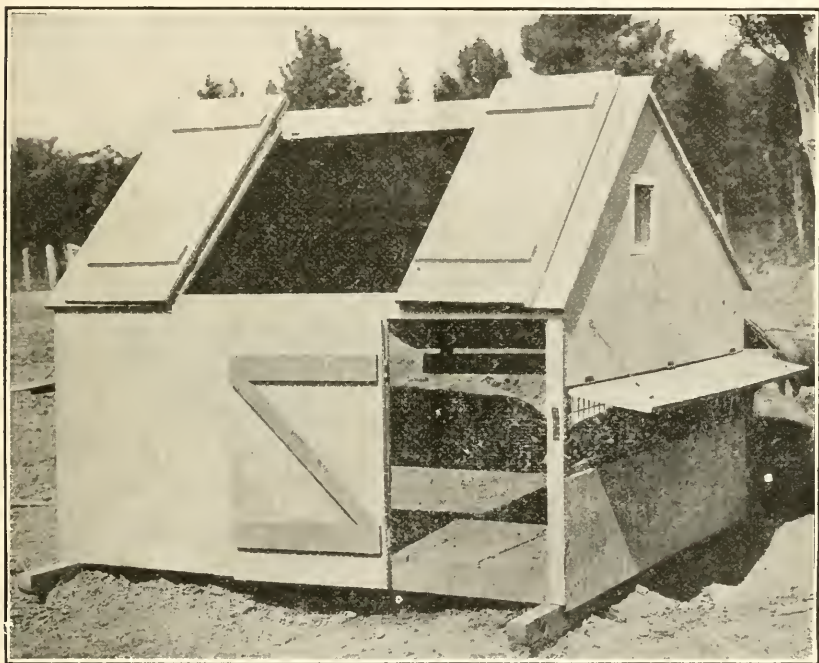


FIG. 4.—Individual or colony house.

and can thus be kept sanitary and made accessible to pastures. There are two general styles of individual houses, namely, the box-shaped with four upright walls and the A-shaped. The dimensions should be 6 feet by 10 feet, or 8 feet by 8 feet. Wooden floors are good, but not necessary. The floor should be higher than the outside level of the ground, to insure dryness. All houses should be sufficiently high to permit the attendant to move about them with comparative freedom. By placing fenders on the walls a few inches from the floor, individual houses may be used for farrowing pens.

Farrowing pens: When a number of sows are kept on a farm it may be desirable to have a regular farrowing pen. A small house pro-

vided with fenders (fig. 5) serves as a farrowing pen. Fenders may be made of 2 by 6 inch scantling and firmly attached to the walls of the pen some 6 inches above the floor. The object of the fender is to prevent the sow overlying young pigs.

Study questions.—What constitutes a good location for a hog house? What are the essentials of a good hog house? Name, describe, and give advantages of the different kinds of hog houses. What kinds of hog houses are found in the community? Which kind is most commonly used? Which seems most satisfactory?

References.—Farmers' Bulletins 438 and 566.

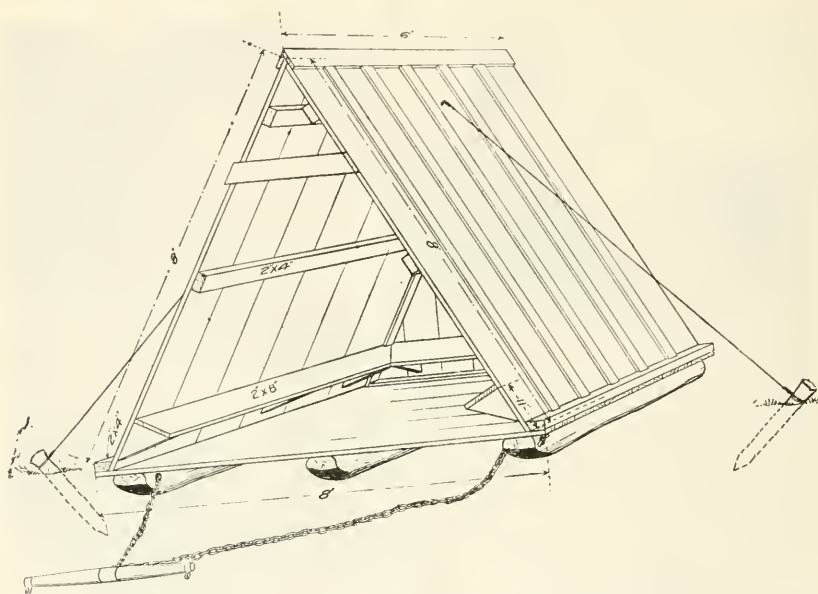


FIG. 5.—A small house provided with fenders.

Practical exercises.—(1) Take the class to visit a modern hog house in the community. Take notes on its location, construction, purpose, and accessories. Make a sketch of the general plan and arrangement. (2) When a visit is impracticable, have members of the class make written reports covering points mentioned in Exercise 1 as to hog houses at their own homes. (3) Pig-project members should provide proper housing for their pigs. The individual house is suitable for pig-project work.

Correlations.—Written work and drawing work are provided in the practical exercises.

Arithmetic: Finding the amount of material, its cost, and the cost of construction of the hog house visited or the houses reported upon by the members of the class provides splendid exercises in arithmetic.

LESSON III.

TOPIC: SWINE JUDGING.

Time.—Fall. Before fairs.

Lesson outline.—Purpose: To know that a hog possesses the necessary qualities for laying on fat or producing good bacon, or for transmitting such qualities to its offspring is important in connection with profitable swine production. There are certain characteristics peculiar to the fat or lard type of hog and the same is true of the bacon type. Those either directly or prospectively interested in swine production should be able to recognize those characteristics. Hence the necessity for judging swine.

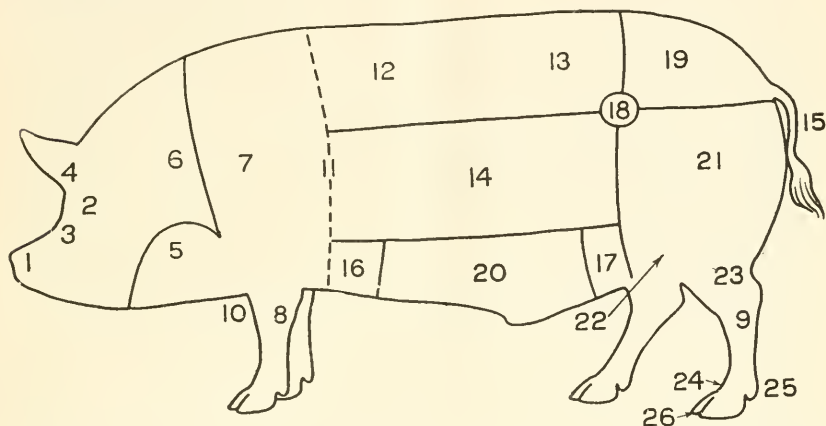


FIG. 6.—Parts of the hog: 1, snout; 2, eye; 3, face; 4, ear; 5, jaw; 6, neck; 7, shoulder; 8, foreleg; 9, hindleg; 10, breast; 11, chestline; 12, back; 13, loin; 14, side; 15, tail; 16, fore flank; 17, hind flank; 18, hip; 19, rump; 20, belly; 21, ham; 22, stifle; 23, hock; 24, pastern; 25, dewclaw; 26, foot.

Parts of the hog (fig. 6): Before attempting the use of the score card the pupils should become familiar with the locations and names of the parts of the hog. The accompanying diagram with its legend should be studied carefully before using the score card.

The score cards: These are merely guides in making detailed studies of the hogs. Arbitrary values are assigned to the various points to emphasize their relative importance. The accompanying score cards should be studied carefully to enable the pupils to become familiar with them before attempting to use them. As much practice as possible should then be given in judging both fat and bacon types of hogs. The teacher should arrange for visits to farms of the community where pure-bred hogs are kept.

SCORE CARDS.

SCORE CARD FOR LARD HOGS.

Breed..... Name..... Register No.....

	Perfect score.	Student's score.	Corrected score.
General appearance, 36:			
Weight, score according to age.....	6		
Form, deep, broad, low, long, symmetrical compact, standing squarely on legs.....	10		
Quality, hair silky; skin fine; bone fine; flesh smooth, mellow, and free from lumps or wrinkles.....	10		
Condition, deep, even covering of flesh, especially in regions of valuable cuts.....	10		
Head and neck, 6:			
Snout, medium length, not coarse.....	1		
Eyes, full, mild, bright.....	1		
Face, short, cheeks full.....	1		
Ears, fine, medium size, soft.....	1		
Jowl, strong, neat, broad.....	1		
Neck, thick, medium length.....	1		
Fore quarters, 10:			
Shoulders, broad, deep, full, compact on top.....	6		
Breast, advanced, wide.....	2		
Legs, straight, short, strong; bone clean; pasterns upright; feet medium size.....	2		
Body, 30:			
Chest, deep, broad, large girth.....	2		
Sides, deep, lengthy, full; ribs close and well sprung.....	6		
Back, broad, straight, thickly and evenly fleshed.....	10		
Loin, wide, thick, straight.....	10		
Belly, straight, even.....	2		
Hind quarters, 18:			
Hips, wide apart, smooth.....	2		
Rump, long, wide, evenly fleshed, straight.....	2		
Ham, heavily fleshed, plump, full, deep, wide.....	10		
Thighs, fleshed close to hocks.....	2		
Legs, straight, short, strong; bone clean; pasterns upright; feet medium size.....	2		
Total.....	100		

Remarks.....

Name of pupil..... Date.....

SCORE CARD FOR BACON HOGS.

Breed.....	Name.....	Register No.....			
			Perfect score.	Student's score.	Corrected score.
General appearance, 36:					
Weight, 170 to 200 pounds, largely the result of thick covering of firm flesh.....			6		
Form, long, level, smooth, deep.....			10		
Quality, hair fine, skin thin; bone fine; firm, even covering of flesh without any soft bunches of fat or wrinkles.....			10		
Condition, deep, uniform covering of flesh, especially in regions of valuable cuts.....			10		
Head and neck, 6:					
Snout, fine.....			1		
Eyes, full, mild, bright.....			1		
Face, slim.....			1		
Ears, thin, medium size.....			1		
Jowl, light, trim.....			1		
Neck, medium length, light.....			1		
Fore quarters, 10:					
Shoulders, free from roughness, smooth, compact, and same width as back and hind quarters.....			6		
Breast, moderately wide, full.....			2		
Legs, straight, short, strong; bone clean; pasterns upright, short; feet medium size.....			2		
Body, 34:					
Chest, deep, full girth.....			4		
Back, medium and uniform in width, smooth, slightly arched.....			8		
Sides, long, smooth, level from beginning of shoulders to end of hind quarters. The side at all points should touch a straight edge running from fore to hind quarter.....			10		
Ribs, deep.....			2		
Belly, trim, firm, thick without any flabbiness or shrinkage at flank.....			10		
Hind quarters, 14:					
Hips, smooth, wide; proportionate to rest of body.....			2		
Rump, long, even, straight, rounded toward tail.....			2		
Gammon, firm, rounded, tapering, fleshed deep, and low toward hocks.....			8		
Legs, straight, short, strong, feet medium size; bone clean; pasterns upright.....			2		
Total.....			100		

Remark.....

Name of pupil..... Date.....

Study questions.—What is the purpose of judging swine? What is a score card? What are the characteristics of a good fat or lard hog? Bacon hog? What are the purposes of the fat or lard hog? Bacon hog? In what respects do the two types differ? Which is better adapted to the community? Have each member of the class make an outline diagram showing the parts of the hog. Name the parts.

References.—Farmers' Bulletin 566. Get State agricultural college publications.

Practical exercises.—(1) The teacher should arrange to give members of the class practice in judging different breeds of pure-bred hogs in the community. Where practicable, secure the assistance of the county demonstration agent or some person especially qualified in this respect. The class should judge the pigs owned by project members.

(2) If a community or county fair is conducted the teacher should take advantage of it to give the members of the class an opportunity to study and judge the best hogs in the community or county.

Correlations.—Require the members of the class to make several copies of the score cards for their personal use.

Making outline diagrams of hogs showing the parts of the hog affords practice in drawing.

LESSON IV.

TOPIC: FATTENING MEAT HOGS.

Time.—Early fall.

Lesson outline.—It is too expensive to fatten hogs entirely on corn and other concentrated feed; hence the necessity for fall pastures and other supplementary feed. During the first part of the fattening period the hogs should have access to good pastures such as cowpeas, soy beans, or peanuts in the South, and alfalfa or clover in the North and West. During this period some concentrated feed should be used to supplement the pastures. It is estimated that fattening hogs when on good pasture should be fed about 2 to 4 per cent of their weight daily of concentrated feed. After the pastures are exhausted the



FIG. 7.—“Hogging down” corn.

hogs should be placed in a small lot and finished off with concentrated feed. During the finishing off period the animals should receive daily 4 to 6 per cent of their weight of concentrated feed.

The practice of “hogging down” corn (fig. 7) has come to be a desirable method of fattening hogs in some sections. The advantage of this method is that the farmer's time is not consumed in gathering and feeding the corn to the hogs. To balance the ration and supply succulent food, it is well to grow with the corn such crops as cowpeas, soy beans, peanuts, rape, pumpkins, and the like. Where peanuts, cowpeas, or soy beans can not be grown it is necessary to feed the hogs alfalfa hay to balance the ration during early stages of the fattening period.

When hogs are being finished off in a small lot corn will, as a rule, constitute the principal part of the ration, yet it should be supple-

mented with nitrogenous and succulent feeds. The following combinations are suggested as rations:

1. Corn, 2 parts, wheat middlings, 1 part.
2. Corn, 2 parts, soy-bean meal, 1 part.
3. Corn, 5 parts, linseed meal, 1 part.
4. Corn, 9 parts, tankage, 1 part.
5. Corn, 1 part, wheat middlings 1 part, skim milk, 6 parts.

Hogs should be kept clean, ample fresh water supplied, and small quantities of succulent feed provided during the finishing-off period.

Study questions.—What forage crops are grown in the community as grazing crops for hogs? What concentrated feeds are used to supplement corn for fattening hogs during the finishing-off period? Have each member of the class submit a statement showing the method of fattening practiced at his own home. This should include the pasture crops, the feed used to supplement pastures and the rations fed during the finishing-off process.

References.—Farmers' Bulletins 874, 411, and 913. Write to the agricultural college of the State for bulletins on the feeding or fattening of hogs.

Practical exercises.—(1) Students carrying on home projects with hogs should have pasturage for their hogs that are to be fattened. Select the pigs to be fattened. Make out rations of concentrated feeds, using those food materials that can be used most economically. These will usually include home-grown feeds.

(2) Members of the class that are not carrying on home projects with pigs should assume charge of the feeding and care of the fattening hogs at home. If feeding is to be done intelligently the hogs should be weighed at the beginning of the fattening period and at intervals of a week or 10 days thereafter. The weights of the hogs provide a basis for calculating the proper amount of feed.

Correlations.—Written reports of methods employed in fattening hogs at the homes of the pupils provide language work.

Calculating rations and the amounts of different kinds of feed needed to fatten the hogs of project members or at the homes of pupils provides interesting exercises in arithmetic. The cost of the materials used in the rations should be based on local prices.

LESSON V.

TOPIC: SELECTING BREEDING STOCK.

Time.—Late fall or early winter.

Lesson outline.—Importance of the brood sow: Influence of the sow upon the offspring is just as great as that of the male. Mismatching or a poor sow will not only give unsatisfactory results in breeding, but it will likely discourage the beginning breeder. This latter fact would be especially true of a youth carrying on a home project with swine.

Qualities of a good sow: If possible, secure a pure-bred animal of a good strain. The forehead should be broad, the throat clean and trim, the neck moderately thin, the shoulders smooth and deep, the back wide and straight, the chest wide and deep, sides straight and deep, the body long and capacious, pelvic region broad and well developed, legs straight and moderately short, and a generally refined appearance; yet overrefinement may indicate a delicate constitution.

If a number of brood sows are to be used they should be uniform in type. This is necessary to secure a uniform lot of pigs. It is very unsatisfactory and unprofitable in breeding to have litters of pigs varying in appearance and lacking uniformity. To insure a uniform result it is advisable to select sows from a well-established strain of hogs.

Importance of the male: As was indicated in the case of the sow, both parents have practically the same influence on the quality of the offspring; however, the male has the greater influence on the entire herd, since every pig is sired by the male, whereas all pigs do not have the same dam.

While too much stress can not be placed on the importance of the sow, if possible the male should be superior to the sow. Regardless of the type of the sow, a poor male should never be used.

Qualities of a good male: Secure a pure-bred animal of a good strain. The masculine characteristics should be strongly developed, especially in the head and neck; the back should be broad, arched and deeply fleshed; sides deep and long; quarters well developed; legs straight and strong. The animal should stand well up on his toes.

Mating: Overrefined sows should be mated to rather masculine males, and coarse sows should be mated to males of high quality indicated by fine bone, skin and hair.

Study questions.—Compare the importance of the sow and the male. If there are pupils in the class doing home project work with pigs, have them compare their brood sows with the qualities set forth as desirable. If members of the class contemplate buying a brood sow or securing the services of a male, they should apply the standards set forth in the lesson.

References.—Farmers' Bulletins 874 and 566.

Practical exercises.—(1) Members of the class who are beginning home projects with swine should select and secure their breeding stock. (2) Those who have grown a litter of pigs should select the animals best adapted to breeding purposes and dispose of them as such. Other pigs should be fattened for meat or disposed of for that purpose.

Correlations.—Have pupils write a brief description of a desirable brood sow.

LESSON VI.

TOPIC: DRESSING AND CURING MEAT.

Time.—Midwinter.

Lesson outline.—Dressing. Killing: This is done by inserting a knife with a narrow straight blade 8 inches long into the hog's throat just in front of the breastbone. The point of the knife should be directed toward the root of the tail in line with the backbone. When the knife has been inserted 6 or 8 inches it should be given a quick turn and withdrawn.

Scalding and scraping: In scalding the best results are had by using water at a temperature of 185° to 195°. Boiling water placed in a cold barrel is ordinarily reduced to a proper temperature. If the water is too cool much time is required in removing the hair and if it is too hot the hair is likely to set. A shovelful of hard wood ashes, a lump of lime, a handful of soap, a little pine tar or tablespoonful of lye helps to loosen the hair.

The hog should not be scalded before life is extinct or the surface blood will be cooked, giving the body a reddish tinge. While being scalded the hog should be kept constantly moving. As soon as the hair and scurf slip easily from the surface scalding is complete. If the water is too hot scald the hind end first; if not, scald the front end in order to get a good scald on the head, which is difficult to clean. Clean the head and feet first. The hands and a knife or a candlestick scraper are all that are necessary to remove the hair. After the hair is practically all removed rinse the body with hot water and shave the remaining hairs with a sharp knife. Raise the gambrel cords, insert the stick and hang up the hog.

Removing the entrails: Split the hog between the hind legs, separating the bones by cutting through the joint with a knife. Next run the knife down the middle line of the body, guiding with the right hand and shielding the point with the left hand. Split the breastbone with a knife or an axe and continue the cut on down to the chin. Remove the entrails. Open the jaw and insert a small block to allow free drainage. Wash out all the blood with cold water. The carcass should now be allowed to cool over night. If the weather is warm remove the backbone to hasten cooling.

Cutting (fig. 8): Pork may be cut as soon as thoroughly cool. Remove the head back of the ears, remove the backbone and the sparerib, cut off the shoulders between the fourth and fifth ribs, and cut off the hams 2 inches in front of the pelvic bones. Trim the hams to smooth rounded pieces. Remove the fat from all parts and take out the loin. Cut the sides into two or three pieces.

Curing meat: The meat should be allowed to cool thoroughly before it is salted. If the weather is cool, 24 to 36 hours is sufficient time to allow for this purpose.

A clean hardwood barrel is a suitable vessel in which to cure meat. To insure cleanliness, scald the barrel thoroughly. Salt, saltpeter, and sugar or molasses are used most commonly as preservatives. Too much saltpeter should not be used, as it is harmful to the health. Two to four ounces per 100 pounds of meat is as much as it is well to use. Salt and saltpeter have a tendency to dry out and harden the meat, hence by adding a little sugar or molasses the meat is softened and the flavor is improved. For each 100 pounds of meat use 5 pounds of salt, 2 pounds of granulated sugar, and 2 ounces of saltpeter. Mix them thoroughly and rub the meat once every three days with a third of the mixture.

The brine-cured meats are considered best for farm use. Brine is less troublesome and at the same time gives better protection against insects and vermin. During warm weather brine should be watched

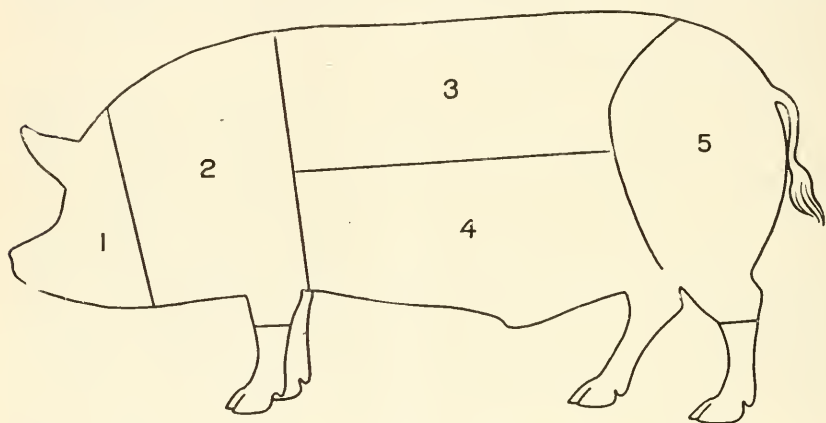


FIG. 8.—Cuts of pork: 1, head; 2, shoulder; 3, loin; 4, belly; 5, ham. Pure-bred Berkshire barrow.

carefully. If it becomes ropy it should be reboiled or new brine made. Ten pounds of salt, 2 ounces of saltpeter dissolved in 4 gallons of boiling water should be used to each 100 pounds of meat. Cool the brine before pouring it over the meat. Meat should remain in the brine three to four days for every pound of meat in each piece.

After the meat has been cured thoroughly by one of the foregoing methods it should be smoked. The meat should be washed thoroughly and permitted to drip before the smoking process begins. The smoke should be provided by a slow fire of some hard wood, such as green hickory or maple. In the winter months the smoke should be kept going continuously until the smoking is completed. During the spring and summer a light fire should be kept going a day at a time every two or three days. This intermittent smoking should be kept up for two weeks, then provide a continuous smoke for 24 to 36 hours and the smoking is completed.

Study questions.—Secure a written report from each member of the class covering the following: How are hogs butchered? What devices

are used in scalding and in elevating the carcass for dressing? What instruments are used in dressing the carcass and in cutting up the meat? What vessels are used in which to cure the meat? What preservatives are used for curing? Give the proportions of the preserving materials used.

References.—Farmers' Bulletin 913. Write to the State agricultural college for publications on dressing and curing meat.

Practical exercises.—Make a study of the community's pork production: (a) How many hogs butchered at each farm? (b) The dressed weight of each hog? (c) The total weight of the hogs dressed on the farms of the community? (d) The value at local prices of the pork dressed in the community? (e) The amount of dressed pork sold and shipped out of the community? (f) The number and value of all the fat hogs sold and shipped out of the community? Tabulate these facts.

Correlations.—Collecting and tabulating the facts called for in practical exercises provide language and arithmetic exercises.

Geography: Does the community produce its supply of pork? If not, in what markets is it purchased? The returns from what money crop are spent for pork? If the community has a surplus of pork, in what markets is it sold? Are other products bought in the same markets? Could they be home grown?

LESSON VII.

TOPIC: SOW AND PIG MANAGEMENT.

Time.—Spring or fall.

Lesson outline.—Care and feed of the sow: Many farmers have their sows farrow during the months of March and April and in the early fall months in the South. Since the weather is often severe in northern sections during March and April, care should be taken to protect the sow from cold. Give her enough straw to make a warm bed, but not so much as to allow the little pigs to get covered and crushed. The sow should have clean water but nothing else for the first 24 hours after the pigs arrive.

On the second day a thin bran mash or skim milk will be relished. Feed moderately for the first week. A mixture of two parts of corn and one of middlings may be fed in increasing amounts until the sow is eating a full feed. If skim milk can be fed in addition to the grain, there is nothing better to make the sow give a full flow of milk. Another good grain mixture for the sow at this time is six parts of corn and one of oil meal. If skim milk is available, the sow will do well on 4 pounds of milk to 1 of corn. A full grain ration for a day should never be more than 4 per cent of the sow's live weight. If the sow can be put on alfalfa, clover, bluegrass, or rape pasture, less

corn will be required. A corn ration of about 2 per cent of the sow's live weight with good pasture makes a cheap and adequate supply.

Care and feed of the young pigs: As soon as the little pigs begin to eat they will do best if fed additional slop in a separate pen and away from their mother and the larger pigs. This can be done by having a pen or a lot where choice clover or other forage crop is growing to which the pigs may have access, but where the opening is so small that the larger pigs can not pass through. When the young pigs are from 8 to 10 weeks old they should be weaned. This often causes a serious check in their growth, but should not do so. When it is desirable to wean the pigs put the mother in a pen leaving a creep for the pigs. Feed the sow sparingly; give water instead of slop and have the grain ration dry. While the sow is receiving a maintenance ration the pigs should be fed all they will consume without waste. A ration consisting of such feeds as skim milk, middlings, corn, and green forage will satisfy the pigs' appetites and simplify the weaning.

Study questions.—What advantages are there in having sows farrow during the early spring months? What precautions should be taken to protect young pigs from severe weather? Give directions for the care of the sow after the arrival of the pigs. Give directions for the care of the pigs until weaned; after weaning.

References.—Farmers' Bulletins 874 and 566. Secure State agricultural college publications on the subject.

Practical exercises.—(1) Students who have home projects with swine should secure a pig and begin to give it attention. If it is the purpose of the boy to go into the work more extensively he should have a sow and litter of pigs to care for. Observe instructions in this lesson.

(2) Boys in the class who are not carrying on projects with pigs should assume responsibility for the care of a sow and litter of pigs from the time the pigs arrive until they are weaned.

Correlations.—Arithmetic: The entire expense in connection with the project should be kept. In projects including a sow and litter of pigs, the feed of the sow should be charged against the pigs until the pigs are weaned. Cash accounting with the growing of the pigs provides exercises in arithmetic.

LESSON VIII.

TOPIC: FORAGE CROPS.

Time.—Spring.

Lesson outline.—Importance: The successful and economical production of pork depends in a large measure upon good permanent pastures supplemented by other forage crops. There should be on an average 1 acre of permanent pasture for each brood sow kept. Green forage is little more than a maintenance ration, and if rapid gains are desired hogs should have a liberal allowance of grain. Growing

forage crops and grazing them off is a good method of improving soils lacking in organic matter.

Kinds of crops: (a) For the cotton belt Bermuda, bur clover, white clover and Lespedeza make good permanent pastures. These should be supplemented by small grains and rape for winter, crimson clover and vetch for spring, cowpeas (fig. 9) and sorghum for summer, corn with soy beans, velvet beans or peanuts for fall. (b) For the Central and Middle Atlantic States, including the bluegrass region, bluegrass should be used largely for permanent pasture. It should be supplemented by rye (fig. 10) for winter, rape (fig. 11) for spring, red clover for spring and summer, corn with soy beans and rape for



FIG. 9.—Grazing cowpeas.

fall. (c) For the Northern and Eastern States bluegrass or redtop provides permanent pasture. Supplementary grazing should be furnished by oats and peas for spring, rape and red clover for summer, and early field corn for fall. (d) For the West grazing is furnished by alfalfa and corn. Corn should be "hogged down."

Study questions.—What is the value of the permanent pasture? Why are supplementary crops necessary? What grazing crops are used in the community for permanent hog pastures? What supplementary grazing crops are grown? Make out a list of seasonal succession crops for supplementary grazing adapted to the community. Compare this list with the crops suggested for your section of the country.

References.—Farmers' Bulletins 874, 272*, 331*, 411, 566, 599*. Write to the State agricultural college for publications relating to the subject.



FIG. 10.—Grazing rye. •

Practical exercises.—(1) Students carrying on home projects with pigs should provide pasturage and supplementary grazing. At least 1 acre of a good permanent pasture should be provided for the



FIG. 11.—Grazing rape.

brood sow and her litter of pigs. Seasonal supplementary crops should also be grown. At least three-tenths of an acre of each crop should be provided for each mature hog.

* May be obtained only from the Superintendent of Documents, Government Printing Office, Washington, D. C.

(2) Make a study of the permanent pastures of the community with reference to the type or types of soil used, the kind or kinds of grass crop, the period of the year during which grazing is afforded, the life in years of each kind of permanent pasture, the method of planting or seeding, the number of acres in permanent pasture on each farm, the total pasture acreage in the community, the percentage of arable land devoted to pasturage, and the average number of hogs an acre of pasture supports.

Correlations.—Tabulating the information called for in Exercise 2 provides written work and exercises in arithmetic.

LESSON IX.

TOPIC: SANITATION AND DISEASES.

Time.—Spring.

Lesson outline.—Sanitation: Hogs should be provided with clean, dry, well-ventilated quarters. Feeding places should be kept clean

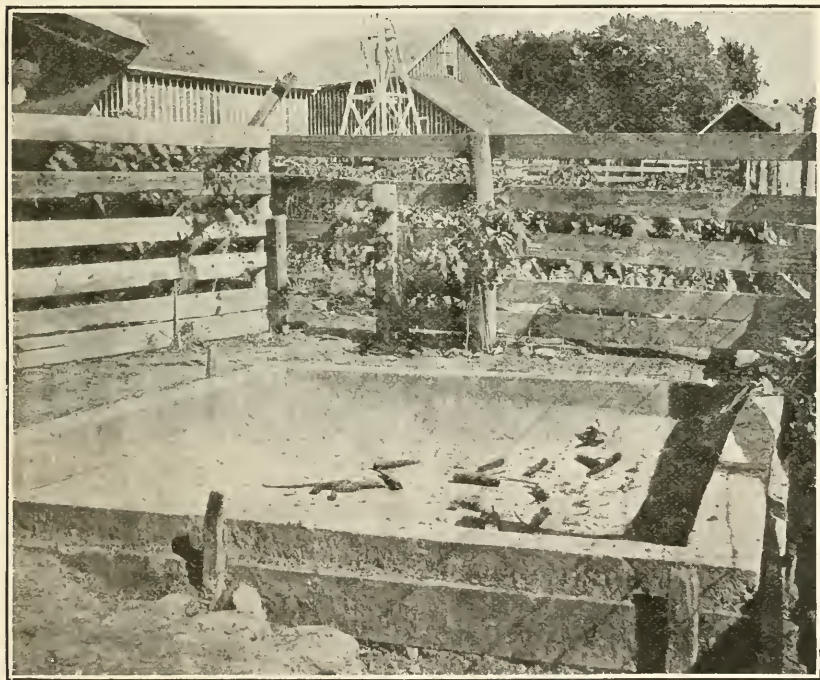


FIG. 12.—A cement wallow—a desirable type.

and the water supply pure. Hogs should be allowed access only to streams the sources and courses of which are known to be uncontaminated. Wallows (fig. 12) should be kept clean and supplied constantly with clean water. The houses and immediate premises should be thoroughly disinfected (fig. 13) once a month with air-slaked lime or a 5 per cent solution of crude carbolic acid. Animals that show indications of sickness should be immediately isolated

and the premises thoroughly disinfected. New hogs brought to the farm should be isolated or quarantined for two weeks before they are permitted to run with the herd.

Hog lice: Hogs, and especially young pigs, often suffer much from this cause. When numerous, lice are a serious drain on vitality, fattening is prevented by them, and hogs so affected are very much more subject to disease. To eradicate lice, dip, spray, or rub hogs with crude oil, crude-oil emulsion, or kerosene-oil emulsion every 10 days for three or four applications.

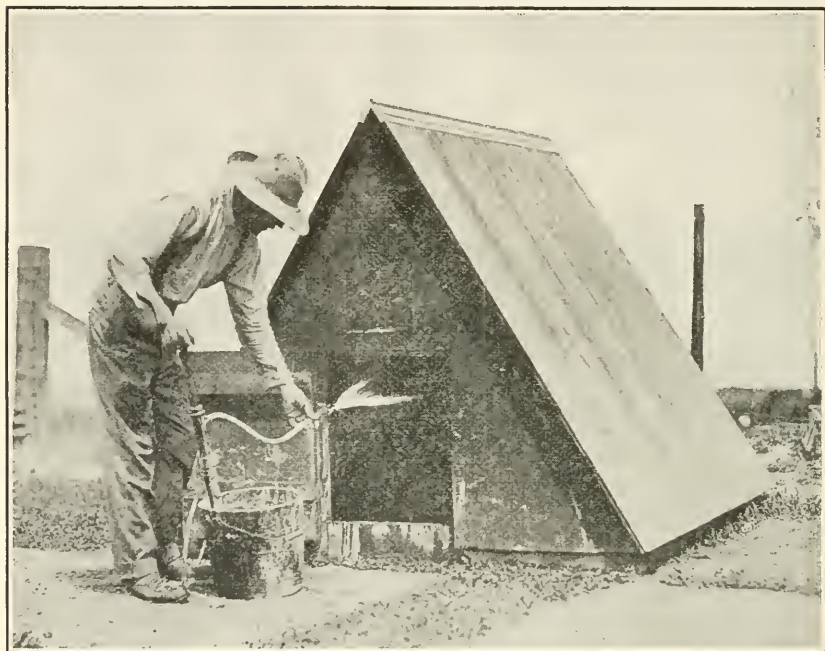


FIG. 13.—Disinfecting a hog house.

Mange: (a) This very troublesome affection with hogs is caused by a mite or parasite that pricks the skin of the hog to get tissue fluid. This injury produces a red spot which finally results in a scale under which mites may be found. (b) The symptoms are itching followed by a loss of hair and thickening and cracking of the skin. (c) Treat mange by applying lime sulphur or nicotine dip once every 10 days for three dippings. Hogs should be washed thoroughly with soap, water, and brush before dipping, to remove the scales.

Hog cholera: (a) The real cause of hog cholera is a very small germ found in the blood or urine. It may be said that anything which tends to lower the health of the animal, such as improper feeding, insanitary conditions of hog lots, damp or cold sleeping places, and

dirty drinking and feeding troughs may be regarded as an indirect cause.

Since the disease can only be started by the introduction of the germ into the herd, and the organism is always present in the bodies of sick hogs and is thrown off in the feces and urine, the most dangerous factor in spreading the disease is the sick animal.

It may get into the herd by sick hogs escaping from a neighboring herd, by the purchase of new stock not showing symptoms, by returning show hogs after visits to fairs or stockyards, and by the purchase of hogs which apparently have recovered.



FIG. 14.—Scrubbing and cleaning the part preparatory to injecting the serum.

(b) The symptoms are not constant and uniform, therefore the disease can not always be diagnosed with absolute certainty. Animals suffering from intestinal troubles, indigestion, and poisoning exhibit symptoms which closely resemble those of cholera.

In the early stages, hogs huddle together; have high temperatures (105 to 107° F. or higher); are constipated; the feces often streaked with blood; a characteristic odor is present; and after the third or fourth day diarrhea develops. As death approaches there is usually a reddening of the skin on the under surface of the body, snout, and ears. This turns into a purple color if death is delayed a day or two. There is a discharge of mucus from the eyes. Coughing may or may not be present. In chronic cases there is emaciation, and patient may linger for days and weeks.

(c) Prevention is the better treatment. Separate sick animals from the herd at once. Vaccinate (figs. 14 and 15) the apparently healthy hogs with antihog-cholera serum. This serum only protects the hogs against cholera. It is a preventive and in no wise a cure. It is advisable to take the temperature of the hogs. This should not be more than 104° F.

Burn or bury the carcasses of hogs that have died with the disease, disinfect all pens and yards after an outbreak of cholera. Burn all manure, litter, and straw, then apply a coat of coal tar. Pens should be situated so that they can be properly drained and cleaned.

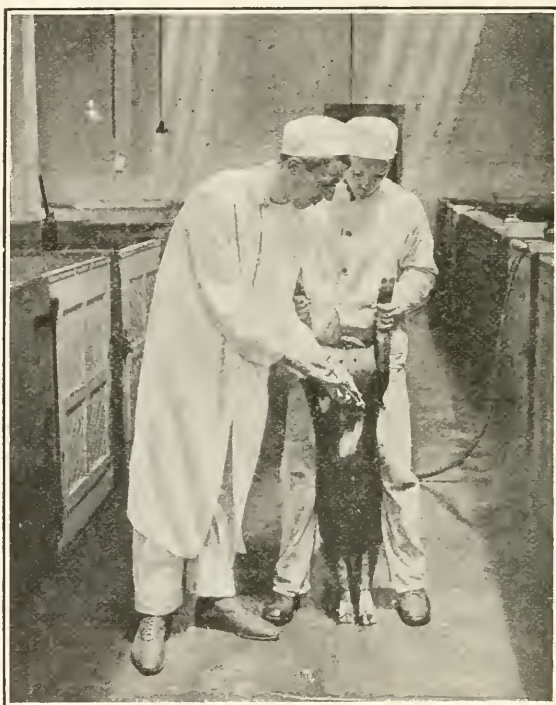


FIG. 15.—Injecting the serum in the flank.

Proper feeding, plenty of exercise, clean pens, and an abundance of sunshine will do a great deal toward protecting hogs from cholera.

Study questions.—What steps should be taken to prevent diseases of hogs? What diseases are most commonly found in the community? What diseases have proved most serious? What methods have been employed to prevent or to eradicate diseases? What type or types of dipping vats are used in the community? Have each member of the class describe a vat that is used at his own home or at the home of a neighbor.

Practical exercises.—Make a study of the diseases of hogs in the community for the preceding year with reference to the following

points: (*a*) The kinds of diseases, (*b*) the number of hogs affected by each disease, (*c*) the treatment used in connection with each disease, (*d*) the number of mature hogs lost from disease, (*e*) the estimated value of such hogs, (*f*) the number of pigs lost from disease, (*g*) the estimated value of the pigs, (*h*) and the total estimated value of all hogs lost from disease. These facts should be tabulated and preserved for study.

Correlations.—Written work and arithmetic problems are involved in the foregoing practical exercises.

PIG-CLUB WORK.

In the use of this publication it is suggested that teachers apply the facts set forth in the lessons to the activities of the pig-club work. For full instructions on pig-club work and record books to be used by members of pig clubs, teachers and pupils should write to the extension divisions of the State agricultural colleges and to the United States Department of Agriculture.

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UNITED STATES DEPARTMENT OF AGRICULTURE
BULLETIN No. 647

Contribution from the Bureau of Entomology
L. O. HOWARD, Chief

Washington, D. C.



May 3, 1918

THE ARGENTINE ANT IN RELATION
TO CITRUS GROVES

By

J. R. HORTON, Scientific Assistant, Tropical and
Subtropical Fruit Insect Investigations

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INTRODUCTION.

The Argentine ant (*Iridomyrmex humilis* Mayr) is a native of tropical America, occurring in Argentina, Brazil, Chile, and Uruguay. It was first introduced into the United States at New Orleans about 30 years ago and was fairly numerous in parts of that city as early as 1891.³ A few years later it had become established thoroughly in and around New Orleans and was causing great annoyance as a household, garden, and field pest. Early it was carried to California, where it has become established widely. It is especially numerous in parts of the citrus districts of Los Angeles and Riverside Counties and in the city of Los Angeles and occurs as far north as San Francisco and as far south as San Diego.

¹ For a discussion of other phases of the Argentine ant problem see Department of Agriculture Bulletin No. 377, by E. R. Barber, entitled "The Argentine Ant: Distribution and Control in the United States."

² Transferred to Cereal and Forage Insect Investigations, Oct. 1, 1917.

³ Foster, Ed. The introduction of *Iridomyrmex humilis* into New Orleans. *In Jour. Econ. Ent.*, v. 1, p. 289-293. 1908.

NOTE.—This bulletin is of especial interest to citrus growers in the southeastern States and generally to the public in that section.

The Argentine ant has been the subject of special study by this bureau for several years, more particularly as to its activity as a house pest, but also as to its general economy in relation to garden, orchard, and field cultures. The facts secured in the investigations¹ prior to 1913 indicated a very important injurious relationship of this ant to citrus culture in Louisiana. As a result of this apparent condition and in response to numerous complaints of injury to citrus trees occasioned directly and indirectly by this ant, a special investigation was instituted in 1913 under the supervision of Mr. C. L. Marlatt, Assistant Chief of the Bureau of Entomology, to determine the exact economic importance of the ant as a citrus pest and to devise effective means of preventing damage in citrus orchards.

GENERAL BELIEF AS TO DAMAGE TO ORANGE TREES.

It has been recognized generally that a few species of ants may injure orchard and other crops either directly, by feeding on plant parts, or indirectly, through their symbiotic relations with scale insects and aphids.

The important features of the activities of ants toward certain scales and aphids, viz., soliciting "honeydew" excretion from them, carrying them about, constructing shelters over them, and combating their enemies, were pointed out more than a century ago by Pierre Huber,² some of whose observations were made upon orange-infesting species. Huber, however, makes no mention of injury caused to orange trees by these habits.

Direct injury by ants, so severe as to cause the death of the trees in orange, cacao, coffee, and cotton plantations in the West Indies, is cited by the French historian Robin,³ contemporaneous with Huber. Robin probably referred to leaf-cutting ants, *Atta* spp., several species of which destroy trees in tropical America by defoliation.

Although the habits of ants in relation to plants and plant pests have been studied by many observers since these early writers, extreme views as to damage to orchard trees by ants, especially through the fostering of insect pests, have developed only since the Argentine ant became established thoroughly in southern Louisiana. This ant made the greatest impression upon people by its unusual abundance and aggressiveness, and became the subject of study by many laymen as well as entomologists. Interest in ants, especially as orchard

¹ Titus, E. G. Report on the "New Orleans" Ant. U. S. Dept. Agr. Bur. Ent. Bul. 52. 1905.

Newell, Wilmon, and Barber, T. C. The Argentine Ant. U. S. Dept. Agr. Bur. Ent. Bul. 122, 1913.

² Huber, Jean Pierre. Recherches sur les Moeurs des Fourmis Indigènes. Paris, 1810.

³ Robin, C[laude] C. Voyages dans l'Interieur de la Louisiane . . . 1802-1807, Tome I, p. 215. Paris, 1807.

pests, as indicated by the number of titles on this subject appearing in entomological literature, has increased greatly throughout the world in the past 10 years.

The principal convictions which had arisen, on the influence of the Argentine ant on citrus fruit trees in Louisiana, are expressed in the writings of Dr. Titus¹ and Messrs. Newell and Barber.² Titus states, substantially, that the ants aid in the distribution of aphids and scale insects on citrus and other trees, remove young scales to new territory, establish colonies of certain species, and appear to have become caretakers for all kinds of scales and plant-lice.

Newell and Barber, in addition to expressing the belief that the ants shelter and protect scale insects, aphids, and white flies, and establish them upon other plants, are of the opinion that it is in the orange groves that this ant has inflicted probably the most serious injury. They note that ant invasion is followed by so rapid an increase of scale insects that, unless prompt measures are taken against the ants, the second year of infestation shows a severe reduction in the crop, the third year almost complete loss, and the fourth or fifth year witnesses the death of many of the trees. These authors state further that the ants are particularly severe in their attacks upon the blossoms of the orange.

The opinion of the Louisiana orange growers themselves on this subject may be summarized from the answers received to inquiries made and submitted in 1914 as to whether the ant injures the trees and in what ways. Of those growers replying to the question, about 61 per cent believed it to be injurious, 33 per cent stated that they did not know, and about 6 per cent believed that it was not injurious. The prevailing beliefs as to the nature of the injury were, (1) that it prevents bearing, (2) destroys blossoms and roots, (3) eats feeder roots, (4) destroys the fruit, (5) takes the sap out of the new growth, (6) causes the death of limbs by traveling continuously over the same spot, and (7) injures the bloom, causing the oranges to drop. It was believed also that the ants increase, disseminate, and protect scale insects and drive out lady-beetles. One answer, however, was to the effect that the ants are beneficial because they destroy other insects. It was generally agreed that the ant causes most severe injury to the orange trees, resulting in a complete loss of crop and culminating in the death of the trees.

A preliminary survey of the orange orchards of Louisiana made it plain that many of them were suffering from some undetermined noxious influences. The trees were, as a rule, undersized, poorly shaped, lacking in the abundance of clear, dark green foliage which

¹ Op. cit., p. 79-84.

² Op. cit.

characterizes the healthy orange tree, and production was far below the standard for trees of their average age. During the blossoming period the flowers were often somewhat too numerous and conspicuous, a condition which characterizes a "sick" tree, and dying and dead trees were numerous throughout the district.

The apparent cause of the diseased condition of the trees was often traced to heavy infestations by scale insects and white flies, but obviously, in some cases, other factors contributed to this condition. Many orchards not invaded by ants exhibited the same symptoms as those overrun by ants. Manifestly, the amount of injury done by the ant must be distinguished from that due to other causes, and this involves a knowledge of the general conditions characterizing citrus culture in Louisiana.

The investigation therefore was planned to cover, first, a thorough study of the habits of the Argentine ant in relation to orange trees, and, second, a study of the cultural practices and other conditions which might affect the successful raising of oranges in Louisiana. An experiment in the reclamation of an ant-invaded and practically abandoned orchard was conducted to determine what might be done in the way of making such orchards profitable. The problem of ant destruction and control in the orchards was taken up at the beginning of the investigation and continued throughout its course.

GENERAL ACCOUNT OF ORANGE CULTURE IN LOUISIANA.

Louisiana is, perhaps, the oldest citrus-producing State in the Union. Orange trees have been cultivated there for at least 200 years and, perhaps, longer, at least one introduction having been made from Cape Haitien (Cap Francois), Santo Domingo, by the original French concessionaires, who arrived in Louisiana in 1718,¹ and it is probable that citrus trees had been grown there by the Spanish colonists previous to this introduction.

During the long period that has elapsed since this introduction orange trees have suffered occasionally from severe freezes, and several times have been killed to the ground. Freezes of this extreme sort, occurring in the period from about 1718 to 1806, are mentioned by Le Page du Pratz,² Robin,³ and several other writers. Similar killing freezes have occurred during the past century, one, in 1835, killing every orange tree from the shores of the Atlantic to the Mississippi;⁴ others, the last one of which at least was equally dis-

¹ Le Page du Pratz. *The History of Louisiana*. Translated from the French of M. Le Page du Pratz, v. 2, p. 17-18. London, 1763.

² *Op. cit.*, v. 2, p. 17.

³ *Op. cit.*, p. 474.

⁴ De Bow, J. D. B. *In Review*, v. 18, p. 609. New Orleans, 1855.

astrous, occurred in 1886,¹ 1895, and 1899.² These freezes had the effect largely to discourage the commercial growing of oranges in Louisiana. Many of the succeeding citrus orchards consisted mainly of volunteer sprouts from the old roots allowed to grow at will without care or culture. After the later freezes considerable nursery stock, untrue to name and poor in quality, was imported into the State. The present citrus industry of Louisiana has developed since the great freeze of 1899, and all the trees now growing have sprung from old roots or have been planted during or subsequent to that year.

Considerable damage also has been sustained by some of the orange orchards from floods due to excessive rainfall and high water and from tidal waves blown in from the Gulf of Mexico and the Barataria section by hurricanes and lesser storms.³ An orange grower informed the writer that such storms had, by washing salt water from the Gulf over the orange trees on the left bank of the river below Pointe a la Hache, caused almost complete abandonment of orange growing in that section. Of the 8 or 10 severe storms of this nature, occurring in the past several years, those of 1893 and 1915 probably caused the greatest damage to citrus orchards. The storm of 1893 was followed by a tidal wave which "engulfed everything before it,"⁴ the water sweeping over the orange groves to a depth of from 3 to 5 feet or more in places, and remaining there for several days. While the present investigation was still in progress there occurred the most severe hurricane of all, that of September 29, 1915. Besides destroying more than 90 per cent of the entire orange crop of the State, and extensively damaging many of the trees by stripping off their leaves and breaking branches, this storm blew water in, at first directly from the Gulf and river; and, on its recurve, brought brackish water, laden with millions of tons of rushes from the Barataria swamps. The water remained about the trees in parts of the orange section for several days, and the rushes were deposited from 3 to 4 feet deep on the ground, many of the trees being laden with them. It is difficult, at present, to estimate the damage that will result from this storm to trees not actually killed; but one way in which it will manifest itself will be in the increased number of poorly formed trees due to killing of the branches by defoliation.

¹ Stubbs, W. C., and Morgan, H. A. The Orange and Other Citrus Fruits. La. St. Agr. Exp. Sta. Special Bul., p. 5, 1893.

² Records of the freezes of 1886, 1895, and 1899 are contained in U. S. Weather Bureau reports.

³ See Humphreys, Capt. A. A., and Abbot, Lieut. H. L., "Report upon the Physics and Hydraulics of the Mississippi River," Washington, 1861, for a record of the earlier floods along the lower Mississippi; and Cline, Dr. I. M., in articles in the U. S. Dept. Agr. Weather Bur. Buls. M (1904) and Y (1913), by H. C. Frankenfield.

⁴ Garriott, E. B. West India Hurricanes. U. S. Dept. Agr. Weather Bur. Bul. II, p. 40. Washington, 1900.

The principal source of damage to the present citrus plantings is, however, neglect of a proper routine of nursery and orchard practice, including control of insect pests. Pruning in the nursery to produce symmetrical trees with the greatest possible production of fruit-bearing wood has been neglected. Later, when planted in the orchard, branches of various sizes are allowed to die from one cause or another, often from scale insects, and the dead wood removed, leaving a misshapen tree. The trees are nearly always planted too close. Owing to the shallowness of the soil¹ the orange roots must spread to a great distance close to the surface, those of the different rows thus meeting and forming a network over the entire orchard. The branches of the various trees in the row also interlace in many cases, resulting in comparatively puny and undersized trees and low production. Furthermore, it is often impossible, at least always difficult, to get about in the orchard to give it the proper cultivation and spraying, and in cultivating the bark frequently is bruised and branches of varying sizes are broken.

Cultivation, fertilization, and spraying are neglected very often or practiced only intermittently. As stated by their owners, about 38 per cent of the orchards are not cultivated at all, the weeds in many of them growing almost as high as the trees. About 10 per cent of the orange groves receive such cultivation as is necessary for the raising of vegetables, which are grown between the rows.

Several classes of fertilizer are used, regularly by some, and intermittently by others. The chief kinds used are cotton seed, either meal or whole, commercial mixed fertilizer, stable manure, and shrimp hulls; sometimes two or more of these are used together. Approximately 37 per cent of the orchards, however, had received no fertilization of any kind for several years. A considerable proportion of the orchards, about 30 per cent, are sown with a cover crop, generally cowpeas.

No standard program of controlling insect pests has been followed, except by a very few of the more progressive growers. According to reports received from 97 per cent of the orange growers of the State, spraying against scale insects, the white fly, and the rust mite has been practiced at one time or another in the last five years by only 15 per cent of those who reported. Some of those who sprayed made only 1 application a year, others as high as 5, and 11 different combinations of insecticides had been used with an

¹ The water table in Plaquemines Parish, where over 90 per cent of the citrus fruit of Louisiana is produced, lies from 1 foot beneath the surface in some orchards to 7 feet in others, but the average depth throughout the parish is only 2½ feet. Draining usually is accomplished by open ditches, from 1 to 2½ feet deep and from 2 to 3 feet wide at the top, leading to an outfall canal, which connects with a bayou of the swamps. In some cases there is a pump, propelled by a gas engine, to hasten the outflow and care for exceptionally heavy rains; and around some groves rear and side levees are constructed. About 40 per cent of the groves, however, have no drainage system.

array of spraying machinery that was even more diversified and inefficient than the insecticides. About 6.5 per cent of those who reported had at one time or another treated for the white fly by spraying the spores of the three or four entomophagous fungi known to attack this insect.

After becoming familiar with the relations of the Argentine ant to the trees and the infesting scale and other insects, the history of the plantings, the natural conditions, and the widespread neglect of good cultural practices, one is forced to conclude that the latter are factors of much greater importance than the ant as causes of damage to and the destruction of citrus trees in Louisiana. The progressive decrease of production occurring in the last five or six years,¹ as well as most of the more severe forms of injury to the trees, is due to a combination of the causes here enumerated. The several armored scales, the white fly, and the rust mite, which, of course, cause much injury to the trees, can be controlled without difficulty in the presence of the ants and regardless of them, as will be shown later. It is possible that under new conditions the citrus mealybug and the fluted scale may become serious pests in the orange groves of Louisiana. The mealybug might become abundant on trees kept clean of other scales and white flies or in the event of a scourge overtaking its natural enemies. The fluted scale, from all reports, already has become a serious pest to ornamental orange and other trees in the city of New Orleans since the present investigation was discontinued, and later may be expected to infest the orange groves.

DISTRIBUTION OF THE ANT IN THE ORANGE GROVES OF THE UNITED STATES.

LOUISIANA.

Data on the distribution of the Argentine ant in the orange groves of Louisiana have been received from the owners or by actual inspection of 99 per cent of the groves of the State. The ants are present in 26.1 per cent, or about one-fourth of these groves. On the west bank of the Mississippi River, from McDonoughville to Home Place, in Plaquemines Parish, the ants are in 62.9 per cent of the groves; from Home Place to Buras, exclusive of the latter, they are present in 77.3 per cent of the orchards; from Buras to Venice, inclusive, they have invaded only 5.5 per cent. On the east bank of the river, in Orleans, St. Bernard, and Plaquemines Parishes, 23.8 per cent of the orchards between New Orleans and Olga, La., are infested with the Argentine ant. Over 95 per cent of the citrus

¹ The actual reduction of the orange crop of Louisiana, based on complete data as to number of bearing trees and amounts of greatest and last (i. e., 1914) crops of 80 per cent of the bearing trees of the State, is 36.8 per cent. The present production, in other words, is only 63.2 per cent of what the orange trees have proved themselves capable of producing.

fruits of the State are produced in these three parishes, so the above figures give an accurate idea of the proportion of the orange groves that come under the influence of the ants. The ant has not yet gained an entrance into any of the seedling orange groves of Cameron Parish.

CALIFORNIA.

In California the ants are present in a considerable number of the groves at Riverside, Corona, Uplands, Duarte, Monrovia, Sierra Madre, Alhambra, San Marino, South Pasadena, Pasadena, and Altadena. They have gained a foothold in one spot in the town of Pomona, but have not yet been reported in any of the orange groves. When they do arrive there, however, they undoubtedly will bring the mealybug into great prominence, as a minor outbreak occurred during the summer of 1916, and conditions are the same there as at Alhambra. They are distributed pretty thoroughly throughout parts of the cities of Los Angeles and Pasadena. In Ventura County they infest some of the groves at Santa Paula and occur in several groves in one block at Fillmore. They have every appearance of having been introduced into this section within the last three or four years. In San Diego County they have not yet gained a foothold in any of the orange groves, but they have been introduced into the fair grounds, in the city of San Diego, where they overrun many of the ornamental plants both out of doors and in the conservatories.

FEEDING HABITS OF THE ANT.

The damage to orange trees by the Argentine ant must be either direct, through habits of feeding upon plant parts and tunneling and nesting about the roots, or indirect, through its relations with harmful insects and as a carrier of citrus diseases, or both. Not only were the nature and amount of the injury inflicted by the ant learned through a study of its foraging and nesting habits, but a successful method of controlling it as well.

It is not the intention here to specify all the foods which the ant has been observed to utilize, or to describe its well-known ravages into household supplies, but rather to describe its feeding habits in the orange groves and particularly in their bearing upon the orange trees. The ant is omnivorous, and though much of its food is derived from plant sources, it exhibits a distinct need for animal food and utilizes not only the flesh but also the excreta and other effluvia of animals as well. Its need for flesh food is so marked that in the artificial formicary, when flesh food is not furnished, it almost always will feed to some extent upon its own young.

FOODS OF THE ANT DERIVED FROM PLANT SOURCES.

METHOD OF THE ANT IN OBTAINING PLANT NECTAR.

The floral, and occasionally extra-floral, nectar of many kinds of plants forms the most dependable food of the ants from a direct plant source. The flowers of citrus and many other cultivated and wild plants are visited habitually for their nectar, which is lapped up from the area around the base of the stamens and petals, this area being evidently the location of the principal nectar-producing glands, at least in citrus.

With the aid of a hand lens the tube-shaped tongue of the feeding ant may be seen moving rapidly and continuously, in conjunction with the labial palpi, over the surface of the floral organs, while the food apparently is being pushed back by a thin, elbowed member that moves constantly within the tube. The ant often continues lapping up the liquid until a full crop is indicated by the distended semi-transparent gaster, this requiring from 15 to 30 minutes. It then usually rests for a period in the flower, or it may at once start its descent toward the nest. On their way down the tree forage-laden ants frequently rest in any sheltered location serving to exclude light and breezes, and almost invariably a group of ants resting motionless may be discovered in such places along the trails.

ANTS POISONED BY FLORAL NECTAR.

Occasionally the ants are poisoned by the nectar from loquat blossoms. On one occasion attention was attracted to a certain group of blossoms by the fact that most of the ants in that neighborhood were assisting sick comrades, carrying dead ants, or standing sluggishly about. Close observation of many of the last mentioned showed them to have the mandibles wide open—rather an unusual attitude. Under a hand lens one was seen finally to open the mouth so wide that the mandibles extended at right angles to the sides of the head and to regurgitate a drop of yellowish fluid. Obviously it was a sick ant. It did not attempt again to feed. The loquat blossom has a heavy, sweet odor peculiarly its own, but suggesting that of the peach or almond, and it seems probable that at times the nectar may contain traces of prussic acid. In addition to obtaining the nectar from the flowers, the ant gets a good proportion of its flesh food there, as will be shown later.

UTILIZATION OF PLANT SAP AND FRUIT JUICES AS FOOD.

The ant also utilizes the unmodified plant sap from orange and some other trees whenever it is able to obtain it. It habitually feeds upon the sap from wounds in the bark and often has been observed working in considerable numbers on every freshly made cut of the

pruning saw in the orange groves, lapping up the sap, just as it does the nectar from flowers, and the sap-laden ants passing from the wounds to the nest in the soil. This habit of visiting cuts and bruises on orange trees may be of importance in the carriage of certain disease germs to places where they may infect the trees readily through wounds.

The ant is very fond of the juice of many kinds of fresh fruits and makes the most of the rotting oranges on the ground and the split fruit on the tree. It may be laid down as a practically infallible rule that the ants do not make the initial break into the rind or peel of fruits. This fact was announced long ago as true of European ants in general by Forel,¹ who, as a result of his observations of these ants on pear, apple, peach, and orange trees, concluded that they never make the first incision through the skin of these fruits. The same is true of the Argentine ant as regards the orange, fig, plum, peach, and loquat in Louisiana. In some orange groves in winter the juice from bruised, decaying, and split oranges forms the ants' principal source of food. The ants also feed to a large extent upon figs when the fruits become soft upon the trees and many fall to the ground. Entrance to even this soft, thin-skinned fruit is gained almost invariably through wounds made by birds and the adult wood-boring beetle *Ptychodes trilineatus* Fab., or through a minute break in the calyx cup or the wrinklelike cracks which commonly form in the skin of the Louisiana fig. As a rule the ants do not carry away particles of the flesh of fruits. The flesh gradually disappears from an attacked fruit because deprived of the juice which constituted most of its mass. On entering a fruit the ants first lick up all the juice ready at hand. A shred of the flesh then is taken in the mandibles and the juice squeezed out and simultaneously lapped up by the tongue. This is repeated until all the flesh of that particular fruit has disappeared.

DIRECT INJURY TO BLOSSOMS AND OTHER PLANT PARTS.

INJURY TO BLOSSOMS.

The ant sometimes chews into the stamens and petals of the orange and other flowers, but by no means habitually, and it is rare indeed that so many blossoms are injured as to cause any loss of importance. After examining thousands of blossoms in the worst ant-infested orchards during three seasons for such injury, it has been necessary to conclude that this activity of the ant is of no economic consequence. In certain situations where the ants are very numerous and desirable food relatively scarce some damage may occur in this way. It occurs

¹ Forel, Dr. Auguste. Les Fourmis de la Suisse, p. 422. 1875.

almost exclusively on isolated trees, where the number of blossoms and of host insects of the ant are low in comparison with the number of visiting ants.

The following points have been noted as being generally true where the ants do use the mandibles on the blossoms: The parts attacked are usually the petals and stamens of open and presumably pollenized blossoms, and in most cases there is no evidence that the fruit is injured thereby. The attack usually begins in a wound made by other insects, and the work of destruction proceeds slowly. As many ants as could be accommodated by the blossoms have been observed to work steadily for one-half day without being able to destroy two petals completely. The ants never have been detected carrying away particles of the blossom tissue; evidently they desire only the juice. The mandibles are used to squeeze the juice out of a portion of the petal or stamen, that it may be lapped up by the tongue. The work of other insects often may be mistaken for that of the Argentine ant in the orange groves of southern Louisiana. Thus the blossoms of both the orange and the loquat may be found badly chewed and ragged, with tunnels cut into the unopened buds, while all are covered with ants inside and out, seeming to make a positive case against the ant. When such cases have been examined with a determination either to see the ants cutting the holes or to discover what did cut them, the real culprit always turned out to be a bud moth,¹ *Uranotes melinus* Hübn., an unidentified case-bearing lepidopterous insect, or katydids.

A few of the flowers other than citrus more commonly visited by the ants in the Louisiana orange groves are those of the loquat or so-called Japanese plum (*Eriobotrya japonica* Lindl.), peach, cow-peas, clovers, dock, goldenrod, and aster.

INJURY TO ROOTS.

The possibility of the ant causing direct injury to plant parts other than the blossoms and fruit, and particularly to the roots, was investigated. In the orange groves the ants habitually nest in the ground near the base of the trees, and often the entrance to the nest will be found directly against the trunk. Many nests in these situations were examined, and both the underground tunnels of the ants and some of the roots of the trees traced for a considerable distance. Dead and dying trees which were said to have been injured or killed by the ants and healthy but heavily infested trees were selected for these examinations.

The principal facts brought to light were as follows: The ants never were found nesting directly in the root clusters of young

¹ Identified by Dr. Harrison G. Dyar.

orange trees. They never were found to have tunneled along the principal roots of the older trees, nor were nests found near enough to these roots to affect them. The smaller roots of sickly and dying trees were generally deficient in number. The most evident cause of the poor condition of these trees was gummosis, the trees in some cases being almost completely girdled by it at the crown, and the bark in this section and for some distance along the principal roots being in a rotten condition. No orange roots were found harboring insects of any kind; there were no host insects of the ant there. In a word, the roots had not the slightest injury traceable to the ants.

FOODS OF THE ANT DERIVED FROM ANIMAL SOURCES.

ANIMAL FOOD OTHER THAN INSECTS.

A considerable proportion of the food of the ant in the orange groves, even aside from the excretions of scales, aphids, and treehoppers, is of animal origin. The ant habitually feeds upon the flesh of all animals, from the round worms to the vertebrates, that become available to it. In addition to the dead and injured insects, which it finds in all sorts of locations, there is a more or less regular supply of the very prevalent crustacean known as the fiddler crab, which constantly is being crushed underfoot, and of certain small fishes occasionally left in the drainage ditches by the sudden removal of water by pumping. The ant also commonly visits piles of discarded oyster shells and feeds upon the particles of flesh adhering at the point of attachment of the oyster. Occasionally it also finds dead birds, field mice, rats, etc. It is unable to break the skin of a rat, as was proved by an experiment, but will clean out the liquids about the eyes and inside the mouth. The ant does not appear to eat muscular tissue in solid form, but shreds it off with the mandibles, lapping up the juices as it works, in the same manner as with fruits. In the artificial formicaries the particles of muscle not eaten are piled up in one of the chambers, and it seems possible that these may be drawn upon at times when meat is scarce.

In the stable the ant constantly visits the manure and captures the larvæ of house flies and other insects. It also visits human excrement, whether directly feeding upon it or solely for the capture of scatophagous insects is uncertain. Large trails have been found of ants carrying dung from chicken coops to the nest, and it appears that the ant may utilize this dry excrement for food. Often it is seen visiting bird's nests for the same purpose, though it also finds among the feathers certain refuse that is attractive to it and, perhaps, captures bird lice to some extent. It also has been seen feeding upon the liquid portion of freshly voided chicken excrement.

It is especially fond of sputum and the mucous secretion from the bronchial and nasal passages, particularly if voided by persons afflicted with a cold. The habit of the ant in getting into the mouth, ears, and nose of infants, whenever opportunity offers, is probably due to its fondness for mucus. Activities such as these, which are habitual with the ants to the full extent that opportunity offers, under certain circumstances obviously may be very important in relation to sanitation.

LIVING INSECTS AS ANT FOOD.

The flesh food most esteemed by the ants seems to be made up of the insects which they capture alive. It is not solely for nectar that they visit the flowers of citrus and other plants, but also for the thrips, gnats, and other insects which they are able to capture there. A certain proportion of the ants foraging in the trees almost invariably are found to be carrying insects. The number so engaged will depend upon the availability of these insects. In a large number of observations on this habit, in all seasons, it was found that from as low as 0.49 per cent to as high as 45.8 per cent of the ants foraging in orange trees carried insects. Usually, however, less than 1 per cent will be engaged in capturing insects, and when the proportion is larger than 5 per cent it is because a special opportunity is offered. For example, on fig trees in Louisiana there is usually a period of emergence of psocids in the spring when other ant food is scarce, and the ants hang around the psocid groups and capture the insects as they emerge. Again, during the blossoming period of the small-leaved privet the ants are able to capture numerous thrips from the blossoms. The blossoms are narrowly campanulate, and the ants, unable to pass between the stamens, await and capture the thrips as they attempt to leave. Large numbers of foraging ants are found carrying white flies at each emergence period of the flies, on both orange trees and privets. All these insects, of course, may be captured from the same trees at the same time. For example, on one occasion, when all the ants carrying insects on a privet tree in one and one-third hours' time were captured and their prey examined, it was found that 32.7 per cent of the prey were thrips (*Frankliniella* sp.), 46.5 per cent nectar-feeding gnats, 13.8 per cent white flies, and 5 per cent psocids. Often, however, they are engaged almost exclusively in the capture of one particular species.

Large numbers of insects are captured on the ground, on weeds and ornamental trees, and in manure piles in the orange orchards of which no special account is taken because their capture has no bearing on the relation of the ants to orange trees. The ants also capture living and dead mealybugs, immature soft brown and black scales,

aphids, immature stages of the white fly, and adult aphid and scale parasites, but so rarely that this activity is unimportant. The more important relationship of the ant as an enemy of the white fly in the adult stage is discussed on pages 38-40.

INSECT EXCRETIONS OR HONEYDEW AS ANT FOOD.

The most dependable, if not the most abundant, supply of food of animal origin utilized by the ants in the orange groves is the honeydew excreted by the several species of soft scales, plant-lice, and tree-hoppers which it attends.

METHOD OF OBTAINING HONEYDEW FROM THE SOFT SCALES, APHIDS, AND TREE-HOPPERS.

The ants can be best observed obtaining sweet excretions from their host insects on the warmer days of winter, as fewer ants are running at such times and they can be observed more closely without disturbing them. The process is essentially the same with one species of host as with another. Taking the black scale, for example, the ant approaches a mature or immature but settled insect and strokes the body with one antenna after the other, rapidly and rhythmically. If no liquid appears after 15 or 20 strokes, the ant usually passes on to another scale or rests motionless by the first. Unless the scales are very numerous a proportion of the ants always are waiting, and the principal function of the small shelter structures found over scale groups is believed to be to protect the waiting ants from light, breezes, and, sometimes, the too copiously falling honeydew and its attendant mold. When the scale is ready to excrete the anal plates open slowly outward and from between them is extruded a tubular organ, at the extremity of which appears a droplet of colorless fluid. This the ant takes and swallows at once. The tube is then retracted and the anal plates close. The whole operation requires only a few seconds, not allowing time for closer examination of the mechanism.

The extreme lightness of the antennal stroke suggests the possibility of the presence of minute sense hairs on the body of the scale, which, if they occur, probably are distributed over the entire surface, as the stroking is not confined to the immediate region of the excretory pore. Attempts to induce excretion by stroking with a hair in imitation of the ants failed. From scales under the microscope there was no response to palpation with hairs of various stiffness. When the shell was pierced with a needle the anal plates half opened reflexly, but not far enough for further observation.

The process is very similar with the mealybug, as the following observation will illustrate: The droplet of mealybug excretion is considerably larger in proportion to the size of the individual insect than that of either the black or the soft brown scale. Two ants were

watched as they simultaneously stroked a mature mealybug on fig. Soon the posterior pair of spines moved slowly apart and a fleshy, pyramidal organ was extruded, at the tip of which there slowly appeared a droplet of colorless excretion. This both ants grasped with their mandibles, one standing at each side, and held until it slowly disappeared down their throats. The excretion was distinctly viscous, as shown by the plainly visible indentations made in the globule by the two pairs of mandibles, and the slowness with which it was swallowed. Ants often have been captured carrying down the tree semisolid globules of mealybug excretion. These they carried in their jaws, as they would carry insects. The excretion of the fluted scale also is voluminous and viscid.

The ants also have been seen to obtain honeydew from a species of treehopper (family Membracidae) occurring on goldenrod in the Louisiana orange orchards. Only the larvæ of this insect (identified by the late Mr. Otto Heidemann as *Entylia bactriana* Germ.) were attended by the ants so far as observed. When ready to excrete, the tip of the abdomen was elevated and a droplet of translucent yellow liquid appeared. This was taken by the ants and carried in the jaws like a minute ball of jelly.

The ants will take the body juices of scales and aphids as readily as their excretions, and the aphids often have been cut with a needle for the purpose of observing this fact.

The ants induce excretion in aphids by stroking with the antennæ, in much the same manner as they do the scale insects. The consistency of the excretion of aphids varies considerably, that from some kinds being thick and jellylike, while from others it is almost watery. An aphid occurring on cypress in Louisiana, for example, excretes a very thick honeydew which the ants swallow slowly and with apparent difficulty. The ants often are seen carrying these semisolid globules of honeydew in their jaws to the nest. Usually the ant hastily seizes the droplet the instant it appears, the liquid being flipped off to a distance if not promptly taken. The black scale also appears to throw the excretion to a distance, though not observed, as much of the sooty mold collects on the upper surface of the leaves which are under the scales. Some of the aphids attended—for example, the common orange-infesting species—have well-developed abdominal protective siphons, but these organs are absent from others.

RELATIONS WITH INSECTS INJURIOUS TO CITRUS TREES.

It has been shown that the Argentine ant is rarely directly injurious to citrus, either through its feeding or its nesting habits. Through the one persistent habit of visiting freshly made wounds

on the trees it may be of great importance as a conveyor of citrus diseases, but the actual extent to which it increases the spread of diseases as yet remains to be determined. Since almost all the damage so far caused by the ant has been through its relations with the injurious citrus insects, this damage must be solely in the nature of an intensification of the work of these insects. Only that portion of such injury in excess of that normally caused by these insects can be due to their relations with the ants. It is, therefore, necessary to bear in mind that only a few of the citrus-infesting insects are of importance, and they cause practically all of the insect injury. The ant must be proved to enhance greatly the damage done by these major pests before a case can be made against it as a destroyer of orange trees. The major pests of citrus in Louisiana are four species of armored scale insects, the citrus white fly, and the rust mite, any one of which will cause more loss than all of the lesser pests, including the soft scales and the aphids, together.

RELATIONS WITH THE ARMORED SCALES.

STATUS OF THE ARMORED SCALES OF CITRUS IN LOUISIANA.

The four important armored scale insects of citrus in Louisiana are, in the order of their importance, the purple scale (*Lepidosaphes beckii* Newm.), the chaff scale (*Parlatoria pergandei* Comst.), the long scale (*Lepidosaphes gloverii* Pack.), and the white scale (*Chionaspis citri* Comst.). The purple scale is the most numerous and destructive of the citrus scales, infesting fruit, leaves, branches, and trunk, and generally incrusting the branches and trunk along with the chaff and long scales. The chaff scale infests nearly every budded bearing tree in the State, incrusting especially the trunk and larger branches, and at times overflowing onto the fruit and leaves in considerable numbers. The long and white scales also occur on most of the trees, but do not become so numerous as the first two, either of which would outrank them both as pests. The status of these scales does not seem to have changed much, excepting perhaps that of the white and chaff scales, in the last 12 or 15 years. The purple scale, according to Morgan,¹ was considered one of the most dangerous scales in the State at that time (1893). The white scale, however, considered by Morgan² as one of the most destructive of the scales, causing bursting of the bark, does not now get so numerous as the others and causes little damage. The chaff scale, which Morgan states was not recognized as very destructive,³ now must be accorded second place to the purple scale as a scale pest of citrus in the State. Dr. Howard states that the chaff scale was the preponderating scale of citrus at a certain plantation on Bayou Têche as early as 1880.

¹ See Stubbs and Morgan, op. cit., p. 57.

² Ibid., p. 64.

³ Ibid., p. 62.

It is worth noting here that the sweet seedling trees of Cameron Parish, which are apparently of Sicilian origin, are much more resistant to these scales than the budded trees. Although the more important scales occur on this type of tree, the infestation is always very light. The citrus white fly, likewise, has not become a pest on the Sicilian seedling trees, and these appear to be especially well adapted to the conditions found in southern Louisiana.

The status of other armored scales of citrus occurring in Louisiana is about as follows: The Florida red scale, which Morgan noted as occurring only at New Orleans and Southport,¹ just across the river, in 1893, is now found scatteringly throughout Orleans, St. Bernard, and Plaquemines Parishes on citrus, palm, banana, oleander, privets, camphor, and other trees. It never has been of more than very minor importance. The California red scale (*Chrysomphalus aurantii* Mask.), a very serious pest in parts of southern California, has been reported on an ornamental tree (*Podocarpus japonica*) in Audubon Park, New Orleans,² and has been observed there by the writer, but does not occur in the orange groves.

THE ANT DOES NOT ATTEND THE ARMORED SCALES OF CITRUS.

The armored scales do not excrete honeydew or any similar liquid attractive to the ants, and are not, therefore, attended by the latter. On the contrary, they probably would become the prey of the ants if it were not for their protective shield or scale. Many hours of observations, extending over a period of nearly three years, on the actions of the ants toward the armored scales have shown conclusively that they do not directly attend the scales either in the expectation of receiving honeydew or of capturing emerging parasites, which, by the way, are neither numerous nor effective. In the course of these observations ants several times have appeared to be palpat-ing armored scales with the antennæ, but on closer examination the real subject of their attentions always has proved to be a young mealybug or other soft scale resting close to the hard scales. The predominance of the armored scales makes impossible that their attendance should escape notice if it occurred.

It was discovered early that ant shelters sometimes occur over large and small groups of the diaspine scales, but this activity could not afford protection of the least consequence to these scales, for the number thus covered is infinitesimally small in comparison with those not covered. That even those scales under the shelters receive only dubious protection from them is shown by the fact that they are often infected with some of the prevailing scale fungi. The fre-

¹ See Stubbs and Morgan, op. cit., p. 60.

² Barber, T. C. The scale insects of Audubon Park. *In* Jour. Econ. Ent., v. 4, p. 450. 1911.

quent occurrence of living soft scales or of remains indicating that such had occupied these shelters is evidence that they generally were built while the ants were attending these scales and had no relation to the armored scales which they covered.

The forced conclusion is that any protection afforded the armored scales by the ants must be incidental and due merely to their presence on the trees and their very manifest habit of attempting to prey upon all insects not supplying honeydew with which they come in contact. For this protection to be so effective as to be of great economic importance the scales must have enemies so efficient as usually to keep them greatly reduced. The fact is, however, that these scales are not kept under reasonable control by their enemies, even in orchards where there are no ants.

PARASITES AND PREDATORS OF THE ARMORED SCALES OF CITRUS IN LOUISIANA.

Although there was not time for a thorough study of the enemies of the armored scales of citrus in Louisiana, great batches of scale material from ant-free orchards have failed to produce more than a sprinkling of internal parasites. The more common hymenopterous parasites, reared from purple and chaff scale material selected because of the frequency of exit holes, were *Aspidiotiphagus citrinus* Craw. and *Coccophagus flavoscutellum* Ashm.¹ A small black lady-beetle,² *Hyperaspis signata* Oliv., with wing covers marked with a spot of red about the middle of each, feeds upon these scales to some extent, and a still smaller ladybeetle, *Scymnus puncticollis* Lec., is suspected of it. Larvæ, pupæ, and adults of a large coccinellid, *Chilocorus bivulnerus* Muls., frequently are found in large numbers upon trees overrun by ants, and a minute black species, *Microweisia misella* Lec.,³ also often occurs on some of the trees by the hundreds. Both of these insects are suspected of feeding upon the early stages of the armored scales, but neither of them seems to be deterred greatly by the ants. At all events, they are found in considerable numbers on trees infested by the ants.

INFLUENCE OF THE ANT ON ABUNDANCE OF ARMORED SCALES IN LOUISIANA.

In addition to prolonged field observations on the relations of the ants to the armored scales, experiments were conducted for the same purpose by excluding the ants from certain trees and noting the effect of their presence or absence on the scales. Thus the ants were excluded from one of two vigorous young orange trees having an approximately equal infestation of the purple scale and allowed free access to the other. Notes were made at intervals on the number of

¹ Identifications by Dr. L. O. Howard.

² Identified by Mr. E. A. Schwarz.

³ Identified by Mr. H. S. Barber.

sound and parasitized scales, the presence or absence of scale enemies, and the activities of the ants. This experiment was started on April 28 and concluded October 24, 1914. There was a large colony of the ants about the base of the nonbanded tree throughout the experiment, but the ants did not visit the tree, except to keep it patrolled by scouts, until several soft brown scales became established there, and at no time were they discovered paying the slightest attention to the purple scales. No scale enemies of any consequence were seen on either tree, and there was never any evidence of parasitism. The results of this experiment are summarized in Table I.

TABLE I.—*Experiment to discover the effect of ants upon the armored scales of citrus. Louisiana, 1914.*

Date.	Ants present.			Ants excluded.	
	Number of sound scales present.	Number of scales showing parasitism.	Number and activities of ants on trees.	Number of sound scales present.	Number of scales showing parasitism.
May 7	97.....	0	Only 3 scouts in tree..	283.....	0
June 3	125.....	0	None on tree.....	591.....	0
June 19	198.....	0	do.....	591.....	0
July 17	276.....	0	8 ants capturing white flies.	530.....	0
Aug. 13	1,130.....	0	A few scouts.....	1,372.....	0
Sept. 25	5,700 (estimated).....	0	10 ants attending soft brown scale only.	7,200 (estimated).....	0
Oct. 24	Trunk and main branches literally covered.	0	50 ants, all attending soft brown scale only.	Trunk and main branches literally covered.	0

Reference to Table I will show that on May 7 there were 97 scales on the ant-invaded tree and 283 on the tree from which ants were excluded. The number gradually increased on each tree from June to October, except that there was a slight and unaccountable decrease on the tree from which ants were excluded during June and July. On September 25 it was estimated that there were 5,700 scales on the ant-invaded and 7,200 on the ant-free tree. By October 24 the trunk and main branches of both were literally covered with the scales, and it was impossible to distinguish between the two as to infestation. The scales had increased at approximately the same rate on both trees. The health of the trees remained good throughout, except for a few yellow spots made on the leaves by the feeding of scale groups.

In another experiment the ants were excluded from a block of more than 200 bearing orange trees for several months, while an equal number of trees adjoining were left untreated as checks. The color of the trees in the treated block showed improvement over those in the check block, and this improvement was attributed to the

cultivation and pruning received by the trees. There was no apparent difference between the two sets of trees as to abundance of armored scales.

RELATIONS WITH THE SOFT SCALES.

STATUS OF THE SOFT SCALES OF CITRUS IN LOUISIANA.

Only four of the six principal citrus-infesting species of soft scales occurring in Louisiana have been discovered in the orange section of Plaquemines Parish. These are the soft brown scale (*Coccus hesperidum* L.), the citrus mealybug (*Pseudococcus citri* Risso), the Florida wax scale (*Ceroplastes floridensis* Comst.), and the barnacle scale (*C. cirripediformis* Comst.). No injury to citrus, serious or slight, ever has been attributed to the last two scales in the history of the orange industry in the United States, nor do they now cause noticeable injury to citrus in Louisiana. The first two are the only citrus soft scales occurring in sufficient numbers in the orange groves to attract attention.

Morgan¹ states that the citrus mealybug was very abundant in some of the orchards of Louisiana in 1893, especially in those well protected from winds and in thick-growing trees such as the mandarin, but was not a particularly serious pest at that time. These statements apply equally well for all practical purposes at present. The mealybugs occur scatteringly throughout the groves of Plaquemines, St. Bernard, and Orleans Parishes. They usually make a strong start in the spring and early summer and threaten seriously to infest certain orchards, but between the middle of June and the first of August they are brought under control by their natural enemies. Infestation goes the same course on fig trees in yards in New Orleans, except that the mealybugs are at times somewhat slower in being subdued there than in the orange groves.

Regarding the soft brown scale, Morgan's statement that "it appears and disappears, being kept in check by parasites, and for this reason has not attracted the attention of the orange growers"² also applies to-day. Its status is still essentially the same, though it is undoubtedly true that this scale will now be found in larger groups, in places, because of abundant attendance by the Argentine ant. It occurs upon nearly every budded orange tree over 3 years of age in the State, and also on banana, rose, and loquat in the orange groves. The important thing is, however, that it does not cause death or serious injury even to the twigs which it inhabits, does not blemish the fruit, and is not of noteworthy economic importance even in orchards overrun by ants.

¹ Op. cit., p. 69.

² Ibid., p. 68.

The black scale (*Saissetia oleae* Bern.) apparently was first noted in Louisiana in 1910, when it was taken upon certain plants in Audubon Park, New Orleans, by Barber.¹ It occurs commonly on oleander in many places about the city, but not a single specimen has been found in the orange groves.

The fluted scale (*Icerya purchasi* Mask.), according to Mr. Ed. Foster, who for many years has been an enthusiastic and discerning observer of insect life about New Orleans, occurred in places near present spots of infestation in and near that city as early as 1891, and this is confirmed by the statements of certain nurserymen and growers. It now occurs in many yards in the uptown districts of the city and in several nurseries, but has not been discovered in the orange groves.

THE ANT AS A PROTECTOR OF SOFT SCALES.

INFLUENCE OF THE ANT ON ABUNDANCE OF MEALYBUGS ON CITRUS IN LOUISIANA.

It was not possible to find sufficiently heavy infestations of mealybugs in the orange orchards of Louisiana during the years 1913 to 1915 to make experiments to determine the relative increase on ant-infested as compared with ant-free trees. Even in orchards overrun with ants the mealybug infestations were scattering and did not persist long enough to permit the desired experiments and observations to be made. The nonimportance of the mealybug as a pest in the orange groves of the State, however, seemed to make it unnecessary to conduct special experiments on them. Nevertheless, mealybugs were fairly abundant on fig trees in the laboratory grounds in New Orleans, and experiments of this nature were conducted on these trees and also on vigorous young orange trees, which were especially colonized with mealybugs for this purpose. The ants first began to frequent the fig trees in large numbers early in April, at which time mealybugs were rare and could be found only in small numbers in the most hidden places, such as old wounds, under dead bark, etc.

On April 27 several groups of mealybugs which still occurred only in hidden places on the trunks and larger branches of the fig were transferred to each of two orange trees. By May 7 they had settled themselves permanently on the trees. Thereafter ants were excluded from one of the trees; in the case of the other, in addition to the ants patrolling it from the ground, a large colony, including 25 queens and many eggs and young, was transferred to the soil in the pot, where the ants took up their abode near the base of the tree. Observations were made at frequent intervals. The number of sound and parasitized mealybugs was counted and notes made on the

¹Barber, T. C. The Coccidae of Audubon Park, New Orleans, La. *In Jour. Econ. Ent.* v. 3, p. 424. 1910.

known or suspected enemies, while the activities of the ants were observed on the unprotected tree. The results are summarized in Table II.

TABLE II.—*Influence of the Argentine ant on abundance of mealybugs on orange, Louisiana, 1914.*

Date.	Ants present.			Ants excluded.		
	Number of sound mealybugs on tree.	Number of parasitized mealybugs.	Number and kind of mealybug enemies on tree.	Number of sound mealybugs on tree.	Number of parasitized mealybugs on tree.	Number and kind of mealybug enemies on tree.
May 7.....	593	0.....	1 T.....	1,126	1.....	1 T.....
May 13.....	234	110 (31.9 per cent.).	2 T.....	859	209 (19.5 per cent.).	4 T, 3 L.
May 21.....	214	3 (1.3 per cent.).	4 D, 3 T, 1 L, 1 S, 1 C.	727	90 (11 per cent.).	3 L, 1 C, 1 S.
June 3.....	20	0.....	0.....	7	0.....	2 D, 1 L.
June 12.....	3	0.....	1 P.....	0	0.....	0.
July 29.....	6	0.....	0.....	0	0.....	0.
Aug. 15.....	2	0.....	0.....	0	0.....	0.

Symbols: T=tubuliferan thrips; L=larva of the pyralid moth *Laetilia coccidivora* Comst.; D=larvæ of the dipteran *Leucopis griseola* Fallén.; C=coccinellids; S=Syrphus fly larvæ; P=the mealybug parasite *Paraleptomastix abnormis* Gir.

At the time of beginning the experiment, May 7, there were 593 mealybugs on the ant-invaded and 1,126 on the ant-free trees. The mealybugs gradually disappeared from both trees, as shown in Table II, until by June 12 there were practically none. There was considerable parasitization and the continuous presence in the mealybug groups of several different predacious enemies. On May 13, for example, 31.9 per cent of the mealybugs on the ant-invaded tree were found to be parasitized, and 19.5 per cent of those on the protected tree also were parasitized. On May 21 the percentage of parasitism among the ant-attended mealybugs was 1.3 per cent, whereas among those on the protected tree it was 11 per cent. Predatory enemies occurred among or near the mealybugs on both trees as long as the mealybugs lasted. The more common ones were predacious thrips, coccid-feeding larvæ of the moth *Laetilia coccidivora* Comst. (identified by Dr. Harrison G. Dyar), and the two-winged fly *Leucopis griseola* Fallén (identified by Mr. Frederick Knab), unidentified lady-beetles, and larvæ of syrphus flies. At least one parasite, *Paraleptomastix abnormis* Gir. (identified by Mr. A. A. Girault), was found on one of the leaves of the ant-infested tree. There was no evidence that the mealybugs were being attacked by fungus or other disease.

The slightly greater persistence of the mealybugs on the ant-frequented tree has little practical significance and in part was accounted for by the following circumstance: On June 12 a strip of

cloth was tied about the branch on which 3 mealybugs still remained on the ant-infested tree to mark their location, and the persistence of mealybugs in this tree after June 12 was due to their being sheltered by this cloth. The instinct for hunting shelter is much stronger in the young mealybugs than in any other of the soft scales and doubtless results from their being the preferred food of predatory insects.

During the course of the foregoing experiment on orange trees the mealybugs on the bearing fig trees, under constant attendance by the ants, had increased gradually, and during May overflowed their hiding place in the crevices of the bark and began to infest some of the smaller branches and leaves. On the branches they formed small groups and infested a considerable number of leaves, spreading along the underside, mostly in singles, twos, and threes. The period of maximum infestation of the fig trees extended from about the middle of May to the latter part of July. On June 26, while at its height, six of the trees were banded and the ants excluded for a period of 98 days, or until October 2, while six others were left unbanded and used as checks.

The work of the enemies and parasites had become evident by the middle of June, however, and it was apparent that the mealybugs were having a struggle to make further headway. By about the middle of July they had begun to lose ground, and from that time very rapidly disappeared from all unsheltered portions of all trees, banded and unbanded alike. The mealybugs very rarely, if ever, succeed in reaching maturity on fig leaves, even on ant-infested trees. A heavy parasitization was indicated early in July, due principally to a small, yellow-brown hymenopterous parasite.¹

After August 15 the few mealybugs remaining on the large fig trees were in protected situations in the bark of the trunk and larger branches. The ant trails also had become thin in the unbanded trees by that time because of the scarcity of mealybugs. As for injury to figs by mealybugs, though a few small groups appeared on some of the fruits of ant-infested trees during this experiment, the percentage of fruits so affected was so small as to be negligible. Practically all the fruit was clean and bright at picking time. The

¹ This insect (*Paraleptomastix abnormis* Gir.) measures about 1 mm. long, some specimens less; general color yellow, marked on head, thorax, abdomen, and wings with smoky gray; the wings with three rows of dusky, broken, transverse stripes near base, middle, and tip, respectively, giving them a spotted appearance; legs and antennæ very long and slender, the former light yellow, the latter smoky brown. The insect has the peculiarity of keeping the wings elevated and in movement when running about on the leaves, which aids in distinguishing it in the field. The technical description by Girault is given in *The Entomologist*, v. 48, p. 184, London, 1915. While this parasite has been introduced into California, in localities in Alhambra, Duarte, and Sierra Madre, it has not yet become established as thoroughly there as in Louisiana, but if it does become so it will be an important factor in reducing the ant-attended mealybug infestations in that State.

leaves were of a clear, bright green, with very little sooting at any time. These trees, however, were receiving better attention than the average yard trees about the city. They had been kept well pruned and braced; weeds had been kept down, and the trees had shown vast improvement over their condition when first taken in charge. At no time during the three seasons in which they were under care was there any large amount of sooting of figs due to mealybugs. The fruit infestations usually were confined to one or two mealybugs in the calyx depression and the collection of a small group at this point on a small number of them.

The mealybug conditions for the years 1913 and 1915 were the same as described for 1914, both on fig trees and on orange trees in the city of New Orleans and in the orange groves proper of Louisiana. The sweet seedling trees of Cameron Parish are apparently not susceptible to the attacks of the citrus mealybugs at all; at least none ever was found on these trees.

Although certain groups of mealybugs may become larger because of heavy ant attendance in Louisiana, the status of this insect does not appear to have been changed by the protection received from the Argentine ant. The mealybugs usually appear in some trees in some of the orange groves as well as on fig trees during April. At times they become numerous enough to attract attention for a few weeks in May, June, and July, but in the last-named month they rapidly disappear, while their enemies increase, and by the last of July or early in August hardly any mealybugs can be found.

The most important enemy of the mealybug in Louisiana appears to be the Sicilian mealybug parasite (*Paraleptomastix abnormis* Gir.). Of the numerous predatory enemies, the most conspicuous were certain lady-beetles, larvæ of the green lacewing flies, larvæ of the small gray fly *Leucopis griseola* Fallén, and lepidopterus larvæ, of which the most prevalent was *Laetilia coccidivora* Comst. The last-named insect has the habit of spinning a more or less tubular web over the mealybug groups and feeding under its protection through the larva period, thus effectively defending itself against ants and other enemies. Another mealybug enemy of less importance, but sometimes fairly prevalent among mealybugs and other coccids, is a species of tubuliferan thrips which has not been identified.

INFLUENCE OF THE ANT ON ABUNDANCE OF MEALYBUGS ON CITRUS IN CALIFORNIA.

In parts of Los Angeles County, Cal., the attendance of the Argentine ant upon the citrus and other mealybugs has a much more pronounced effect in favoring persistent, heavy infestation than in Louisiana. This is especially the case with healthy trees that are

comparatively free from other infesting insects. Several experiments were conducted in that county in the summer of 1916 which bring out pretty well the varying effects of ant attendance on the mealybugs under different conditions.

EXPERIMENT I.

The subject of Experiment I was an orange tree whose 6 main branches had been cut back to stubs about 2 to 3 feet long. Three of the stubs, with 28 new shoots, were banded to exclude the ants, while the other 3, with 27 shoots, were left free to the ants. Mealybug infestation, prevalence of mealybug enemies, ant attendance, and vigor of tree were noted at intervals from the beginning of the experiment, April 14, to its conclusion, September 2, 1916. The results are summarized in Tables III and IV.

TABLE III.—*Effect of the Argentine ant on abundance of mealybugs on orange. Los Angeles County, Cal., 1916.*

Date.	Ants present.		Ants excluded.	
	Mealybug infestation.	Number of mealybug enemies seen.	Mealybug infestation.	Number of mealybug enemies seen.
Apr. 14	74 clusters and groups.....	28	73 clusters and groups.....	35
May 3	106 groups.....	89	83 groups.....	76
May 17	361 groups of 10 to 150 bugs each.....	19	45 groups of 10 to 30 bugs each.....	38
July 6	112 groups, 10 to 50 ovipositing females with egg masses.....	38	12 ovipositing females only with egg masses; 9 masses of destroyed mealybug material.....	15
July 17	As on July 6, but more young scattered over leaves.....	301	No living mealybugs.....	0

The larger groups or clusters of mealybugs at first occurred on the main branches, where they had passed the winter, but the migrating young formed smaller but populous groups at the bases of the smaller branches and of the leaves. It will be noted that at the outset of this experiment there was nearly complete uniformity in the amount of infestation between the branches from which ants were excluded and those to which ants had access. Substantial uniformity of infestation persisted up to May 3, when there was a somewhat greater number of groups of mealybugs and more scattered individuals on ant-invaded branches than on those kept free from ants. Between May 3 and July 17 the mealybugs rapidly diminished to complete disappearance on the branches from which ants were excluded, whereas on those to which ants had access mealybugs continued to increase rapidly for a time, reaching the high point of infestation on May 17. Thereafter the infestation decreased on these branches also, but much more slowly than on those

from which ants were excluded, remaining, on July 17, about one-third as heavy as on May 17.

Up to July 17, therefore, the presence of the ants had a very notable effect in increasing and maintaining mealybug infestation. On this date the band was removed from one of the branches so that reinfestation under ant attendance might be observed, and one of the branches previously free to ant attendance was banded. No marked results were obtained from this test. As indicated in Table IV, a slight reinfestation of mealybugs occurred on all the branches free from infestation on July 17, but there was a general decrease of infestation on both types of branches and on the entire tree throughout August. The only living mealybugs remaining on either set of branches during August were young which were scattered over the leaves, the insects being destroyed by their predatory enemies before reaching maturity, and by September 2 the entire infestation on the tree was reduced to an insignificant amount. In other words, on this particular tree the effect of the ant in increasing and maintaining the mealybug was marked up to the middle or end of July, but this effect was practically lost during August.

TABLE IV.—*Effect of the Argentine ant on abundance of mealybugs on orange, Los Angeles County, Cal., 1916.*

Date.	Ants present.								Ants excluded.							
	From Apr. 14 to Sept. 2.				From July 17 to Sept. 2.				From Apr. 14 to Sept. 2.				From July 17 to Sept. 2.			
	Number of leaves examined.	Number of living mealybugs.	Average number of mealybugs per leaf.	Number of mealybug enemies.	Number of leaves examined.	Number of living mealybugs.	Average number of mealybugs per leaf.	Number of mealybug enemies.	Number of leaves examined.	Number of living mealybugs.	Average number of mealybugs per leaf.	Number of mealybug enemies.	Number of leaves examined.	Number of living mealybugs.	Average number of mealybugs per leaf.	Number of mealybug enemies.
Aug. 7	50	1,000	20	9	189	21	0.111	0	405	81	0.2	0	150	30	0.2	1
Aug. 16	153	575	3.6	31	382	71	.18	1	251	122	.4	2	128	19	.14	17
Sept. 2	1,750	216	.12	0	1,465	50	.03	0	1,690	43	.02	0	1,645	49	.07	0

¹ All of the leaves examined.

The efficiency of natural enemies, as affected by the ant, was seen in the first period of the experiment, from April 14 to July 17. From April 14 to May 17 the number of mealybug enemies occurring on the branches from which ants were excluded did not differ widely from that on branches to which ants had access; yet, although by the latter date these enemies had reduced greatly the number of mealybugs on branches kept free from ants, their effect on mealybugs attended by ants was negligible. It appears that the mealybug predators are able to avoid capture by the ants, but are incapable of reaching the mealybug groups closely attended by them.

From May 17 to July 17 the mealybug enemies rapidly decreased and disappeared from branches kept free from ants and greatly increased on those where ants were present, following, as would naturally be anticipated, the available food supply. In the succeeding period of the experiment, from July 17 to September 2, after a certain amount of fluctuation, depending upon the supply of host insects, the natural enemies finally disappeared from all branches with the practical disappearance of their prey.

EXPERIMENT II.

The second experiment was conducted in the same locality, at Alhambra, Cal., on eight bearing navel-orange trees, four of which were banded with adhesives on April 24 and kept free from ants, while the alternating four were left accessible to ants for comparison. The results of this experiment, which are summarized in Table V, were similar to those in the preceding experiment, except that on the ant-invaded trees heavy mealybug infestation persisted throughout the experiment, or until September 12.

TABLE V.—*Effect of the Argentine ant on abundance of mealybugs on orange trees, Los Angeles County, Cal., 1916.*

Date.	Ants present.				Ants excluded.			
	Mealybug infestation.				Mealybug infestation.			
	On fruits.			On other parts of trees.	On fruits.			On other parts of trees.
	Total number examined.	Number infested.	Per cent infested.		Total number examined.	Number infested.	Per cent infested.	
May 24	800	1 200	25	Approximately as on Apr. 24.	800	1 150	18.7	Approximately as on Apr. 24.
July 10	1,405	328	24	242 groups of 1 to 5 mealybugs.	1,154	5	.43	12 groups of 1 to 5 mealybugs.
July 24	1,261	766	60.7	296 small groups, many scattered young.	1,263	34	2.6	7 small groups, many scattered young.
Aug. 7	1,596	923	57.8	206 small groups, many scattered young.	1,288	91	7.	Many scattered individuals.
Aug. 31	1,310	728	55.5	Many scattered.....	1,086	59	5.4	None.
Sept. 12	1,249	421	33.7	do.....	1,282	64	4.9	Do.

¹ From 1 to 5 mealybugs hidden under the sepals only of each infested fruit.

At the beginning of this experiment, April 24, mealybug infestation was slight, only 103 scattered individual mealybugs and small groups occurring on the trees from which ants were excluded and 70 individuals and small groups on those to which ants were allowed access, the ant-excluded trees being slightly more infested.

On May 24 young mealybugs were found concealed under the sepals of 25 per cent of the young fruits on the ant-invaded trees

and 18.7 per cent of those on ant-excluded trees, showing a slight tendency toward worse infestation under ant attendance. The marked tendency of mealybugs to establish themselves under the sepals of the young fruits and in similar situations to secure sheltered feeding places must be taken into account when considering the subject of the transfer of mealybugs by ants to establish new colonies.

Between May 24 and July 24 mealybug infestation rapidly increased on the trees to which ants had access, while it decreased, with slight fluctuations, to an almost insignificant amount on those from which ants were barred. From July 24 to September 2 there was a slow reduction in the amount of mealybug infestation on the ant-traversed trees, an increasing number of mealybugs' remains indicating increased effectiveness of the natural enemies, which had become more numerous following the food supply. On the trees from which the ants were barred the mealybug infestation in the same period, with minor fluctuations in which the highest point was slight infestation of 7 per cent of the fruit, was maintained at a negligible amount.

The most important early activity of mealybug predators occurred on the very small fruits, these insects occurring with mealybugs under the sepals as soon as the mealybugs arrived there and preventing the growth of infestations from these spots. From July 24 to the close of the experiment, September 12, the number of predatory enemies, again following the available supply of food insects, was greater on the trees traversed by the ants than on those from which ants were barred, there being from five to eight times as many on the former as on the latter trees at the times examined. The principal enemies of the mealybugs occurring on these trees were Coccinellidae, Hemerobiidae, Chrysopidae, Pyralidae, and Syrphidae. During this latter period of the experiment, following the decrease in percentage of infested fruits on the ant-traversed trees, the increasing effectiveness of the mealybug enemies was manifested in the occurrence of an increasing number of fruits which had been rid of mealybugs, their previous infestation being indicated by bits of cottony secretion, sooty mold, etc.

EXPERIMENTS III AND IV.

Two other experiments conducted at Alhambra, Cal., with nursery trees and potted seedling orange trees brought out very similar results. The nursery trees, owing to too late transplanting, failed to thrive and did not become very heavily infested with mealybugs, but showed less plainly but quite as certainly the results of ant attendance in increasing these insects.

In the experiment on potted orange seedlings, 6 of the young plants were infested artificially with mealybugs, and on May 17,

after the mealybugs had become located, the ants were excluded from 3 of the plants on which there were 4,573 young bugs and allowed free access to the remaining 3, on which there were 3,094 mealybugs. On August 21 there were only 577 mealybugs left on the plants from which ants were excluded, 40.6 per cent of the leaves being infested with an average of 3.2 mealybugs each; whereas on the plants traversed by ants there were 5,461 mealybugs, 74.5 per cent of the leaves being infested with an average of 29 mealybugs each.

EXPERIMENT V.

In the fifth experiment, which was conducted at Duarte, Cal., it was demonstrated that the effect of the ants in increasing the abundance of mealybugs may be largely neutralized in the presence of unchecked infestation by the black scale (*Saissetia oleae* Bern.). Ten bearing naval-orange trees of about equal condition and equal mealybug, ant, and black-scale infestation, the last-named being heavy, and with fully 90 per cent of sooting of the leaves, the trees not having been fumigated since 1913, were selected for this experiment. On April 20 five of the trees were banded with adhesive mixture to exclude ants, and the alternating five left accessible to ants for comparison. The results of this experiment are summarized in Table VI.

TABLE VI.—Effect of the Argentine ant on abundance of mealybugs on orange trees heavily infested with the black scale (*Saissetia oleae*). Los Angeles County, Cal., 1916.

Date.	Ants present.				Ants excluded.			
	Mealybug infestation.				Mealybug infestation.			
	On fruits.			On other parts of trees.	On fruits.			On other parts of trees.
	Total number examined.	Number infested.	Per cent infested.		Total number examined.	Number infested.	Per cent infested.	
May 25	100	80	<i>Per ct.</i> 80	Many scattered mealybugs and small groups.	100	94	<i>Per ct.</i> 94	Many scattered mealybugs and small groups.
July 7	437	156	35.6	11.4 per cent of new shoots infested.	304	165	54.2	33.1 per cent of new shoots infested.
July 21	455	154	33.8	51 groups of 1 to 30 young and 17 adults with egg masses.	382	193	50.5	36 groups of 1 to 15 young and 47 adults with egg masses.
Aug. 15	409	143	34.9	81 groups of 1 to 5 mealybugs each.	376	165	43.8	20 groups of 1 to 5 mealybugs each
Sept 11	364	198	54.5	79 groups of 1 to 5 mealybugs each.	340	137	40.2	41 individual mealybugs only.

The initial mealybug infestation, on April 20, was much greater on these trees than on those used in experiment No. 2, there being on the trees left free to ants 1,661 individual mealybugs and small groups, and 10 infested ripe fruits; and on those from which ants were excluded, 1,896 individuals and small groups and 4 infested ripe fruits.

There was no appreciable increase of infestation between April 20 and May 25, but on the latter date a few mealybugs occurred under the sepals of many of the little fruits, a larger percentage of infestation occurring on the trees from which ants were excluded than on those to which they had access.

Between May 25 and July 7 the intensity of fruit infestation increased on all trees, though the percentage of fruits infested decreased. On July 7 about 18 per cent more fruits and 22 per cent more new shoots were infested on the trees protected against ants than on those frequented by them; and, while several fruits on the latter were infested more severely than any on the former, the trees free from ants continued to suffer a larger amount of fruit infestation from July 7 to August 15.

From August 15 to the close of the experiment, on September 11, the infestation was slightly worse on the trees to which ants had access. With the exception of such minor fluctuations as those indicated, however, the amount of mealybug infestation remained practically the same on ant-invaded trees as on those free from ants throughout the period from July 7 to September 11.

The struggle of the mealybugs to find suitable spots to feed and avoid their natural enemies on these scale-infested trees was marked. Every available spot free from sooty mold was occupied by them, and groups often occurred under sheets of the mold where it had lifted from the leaf. Even on the fruits the mealybugs were crowded by the black scale, and the practically equal and slight infestation on both sets of trees was due largely to this crowding.

Mealybug enemies were numerous on both sets of trees throughout the experiment, especially the green and the brown lacewings, and larvæ of the green frequently were seen feeding upon larvæ and cocoons of their own kind and of the brown lacewings. Bits of cottony secretion of the mealybugs entangling the exuviae of mealybug enemies were numerous at every examination. Others of the more numerous mealybug predators were the lady-beetles *Hyperaspis lateralis* Muls. and *Rhizobius ventralis* Erh.,¹ the predacious caterpillar *Holcocera iceryaeella* Riley,² the predacious fly *Leucopis bella* Loew, and the predacious bug *Zelus renardii* Kolen.

¹ *R. ventralis* is primarily a black-scale enemy, but it also feeds upon mealybugs.

² Identified by Mr. Carl Heinrich.

EXPERIMENT VI.

In the following experiment, verifying the results of the one preceding, 4 trees longer subject to unchecked black-scale infestation were used, 2 of them being banded on June 2, the other 2 left free to ants.

TABLE VII.—*Effect of Argentine ant on abundance of mealybugs in the presence of heavy black-scale infestation on orange. Los Angeles County, Cal., 1916.*

Date.	Ants present.			Ants excluded.		
	Fruit infestation.			Fruit infestation.		
	With mealybugs.	With black scale.	With sooty mold.	With mealybugs.	With black scale.	With sooty mold.
	<i>Per cent.</i>	<i>Per cent.</i>	<i>Per cent.</i>	<i>Per cent.</i>	<i>Per cent.</i>	<i>Per cent.</i>
June 2.....	37.5			32.5		
July 7.....	32.9	94.4	100	20.2	100	100
Aug. 15.....	48.1	53.5	100	20.5	45.7	100
Sept. 11.....	39.6	91.7	100	21.2	98.7	100

The fruit infestation on different dates, summarized in Table VII, shows that mealybugs were always somewhat more numerous on the fruit patrolled by ants, but that almost no change in degree of infestation occurred on either lot of trees. Most of the fruit on all trees was infested with young black scales, and all was sooty throughout the experiment.

RELATION OF THE ANT TO MEALYBUG OUTBREAKS IN SOUTHERN CALIFORNIA.

The foregoing experiments establish beyond a doubt that the attendance of ants upon mealybugs in Los Angeles County, Cal., has the effect of greatly increasing their abundance, particularly during the first half of the summer, upon healthy trees comparatively free from other scale insects, causing severe infestations where otherwise they would be so scarce as hardly to come to notice at all.

This does not mean, however, that the mealybug outbreaks do not occur in southern California except in the presence of ants. More than 300 outbreaks of the citrus and other species of mealybugs were reported during the summer of 1916 in and about Pasadena by Dr. A. G. Smith, the local county inspector. The writer inspected 167 of these for ants, but, while the Argentine ant was present in 72 of them, and other ants in 16 more, there were no ants in the remaining 79. Nevertheless, it is a fact that in Los Angeles County the enemies of the citrus mealybug bring it under control early in the season and generally cause its almost complete disappearance when there are no ants present to prevent.

Most of the mealybug outbreaks in Los Angeles County orange groves which came to attention during the summer of 1916 did not long remain very severe unless the Argentine ant was in attendance. An outbreak that occurred at Pomona may be cited as an example of what usually occurs under such circumstances. The mealybugs appeared in the orange trees in a certain locality and on walnut trees bordering the groves in April and May and were rather numerous on many trees during the latter month. By June 23, however, they had become so scarce that it was difficult to find them at all. None could be found on the walnut trees, and though some orange trees were found on which 15 out of 18 of the young oranges were infested, there were only from 1 to 10 mealybugs per fruit, hidden under the sepals. Predacious caterpillars, tubuliferan thrips, and small lady-beetles (*Scymnus* sp.) were also rather common under the sepals of these fruits and apparently feeding upon the mealybugs. The Argentine ant did not occur in this section, and there were no other ants in the worst infested trees at the time of this examination.

In San Diego County, on the contrary, the mealybug infestations were very bad in some of the groves where there were no ants in attendance at the time of the inspection, June 27 and 28. In the Lemongrove district three orchards were inspected, and all trees examined were infested very badly with mealybugs. In two of the orchards there were no ants of any species on the trees examined, but in the third a few small red ants occurred on some of the trees. The Argentine ant is not yet present in any of the orange groves of this county, although it has been introduced into the fairgrounds at San Diego. In the Sweetwater Valley the lemon trees inspected also were infested very badly with mealybugs, but while two species of ants were fairly common on some of the trees, the Argentine ant was not present. The infestations were equally as bad on a number of trees on which there were no ants as on those where the ants occurred.

In the Chula Vista district the infestation in the last two or three years had been quite as severe as at Lemongrove and in the Sweetwater Valley, but during the summer of 1916 it was so slight as to give no apprehension. This fact is attributed locally to the occurrence of mealybug enemies, and especially the lady-beetle *Cryptolaemus montrouzieri* Muls., in much greater numbers this year than usually.

In the El Cajon Valley, which is considerably farther inland than the three orange districts previously mentioned, and is almost completely shut in from air currents from the coast by the surrounding foothills, no mealybugs could be found, and Mr. H. M. Armitage, horticultural commissioner of San Diego County, stated that none had been found by the local inspectors.

In San Diego County, therefore, the conditions are such that the mealybug infestation is just as persistent in trees where there are no ants as in other localities overrun by them. This infestation may remain severe for from one to several seasons, and then there will come a period when the mealybugs will disappear almost wholly. This fact has just been illustrated in the Chula Vista district, and is no doubt due to variations in abundance of the mealybug enemies in that section.

INFLUENCE OF THE ANT ON ABUNDANCE OF OTHER MEALYBUGS IN CALIFORNIA.

The number and severity of outbreaks of other species of mealybugs in Pasadena have been increasing during the last three years. Dr. A. G. Smith, county horticultural inspector for the Pasadena District, states that in an inspection five years ago, covering the district bounded by Fair Oaks, Colorado, and Lake Streets and the Altadena boundary line, only one mealybug infestation was found. An inspection three years ago of the same section of Pasadena produced 18 infestations, mostly on rice-paper plants. During the summer of 1916, up to the time this information was given, only the north half of this section, or from the Altadena line to North Orange Grove Avenue, had been inspected, but infestations were found in numerous places and on many more host plants than ever before. The worst of these outbreaks have occurred in territory invaded by the Argentine ant, and undoubtedly have been especially severe and persistent only where attended by this ant.

A number of the outbreaks discovered by Dr. Smith's inspectors early in the summer of 1916 had been greatly reduced, and the mealybugs had almost disappeared by August where there were no ants in attendance. The species concerned in these outbreaks and the host plants most commonly infested in this section are as follows: *Pseudococcus citrophilus* Claus. on pittosporum, bignonia, tecoma, citrus; *Pseudococcus bakeri* Essig. on Chamaerops and Washington palms, peppers, laurestinas, nightshade, tomato, banana, aralia, fig, camphor, and various garden plants; *Pseudococcus longispinus* Targ. on Dracaena palms, citrus, and some shrubs; *Pseudococcus ryani* Coq. on cypress hedge. Outbreaks of these species of variable degree occur every spring, but are less persistent and usually are controlled early by their natural enemies where no ants are present.

Another species, known as the golden mealybug (*Pseudococcus aurilatus* Mask.), attacks the Araucaria tree in many localities about Pasadena and remains numerous throughout the summer, regardless of whether ants are present or not, and often causes the defoliation of the trees. This mealybug either is not controlled by

the various predators to the same extent as are the others mentioned above, or there may be some relation between it and its favorite food plant which makes this insect distasteful to these predators.¹

INFLUENCE OF THE ANT ON ABUNDANCE OF THE FLUTED SCALE IN LOUISIANA.

The fluted or cottony cushion scale (*Icerya purchasi* Mask.) ranks second only to the mealybugs as to preference by the Argentine ant, owing, as with the mealybugs, to the large amount of viscid excretion given off by the insect. In spite of heavy attendance by the ant, however, the fluted scale has not been able to thrive and become abundant in Louisiana, except during the last season in New Orleans. This scale is believed by some, as previously stated, to have occurred on Metairie Ridge and in various places in New Orleans prior to the destructive freeze of 1895. Whether this is true or whether the insect has been imported into Louisiana only in very recent years is not certain. At all events the insect did not come to attention in the State until the fall of 1912, when it was found by the State inspector.² During the years 1913 to 1915, inclusive, closer attention was paid to the insect, and it was found at various places in New Orleans. Still it did not occur in the orange groves, and the infestations in and about the city were very scattering. Whenever they occurred in some numbers on a plant, they were viewed with such apprehension that extermination was attempted. It was, therefore, impossible to get a sufficient infestation under suitable conditions for experiments to determine the influence of the ant on their increase. During the summer of 1916, judging from reports received from New Orleans, the fluted scale spread more rapidly and became more numerous about the city than at any previous time, but the exact part played in this increase by the ant is not known.

INFLUENCE OF THE ANT ON THE FLUTED SCALE IN CALIFORNIA.

The status of the fluted scale in California in recent years is given by Quayle,³ who states that the infestations become as bad at times in some localities as when at their height in earlier years. As a rule, however, the insect does not become numerous enough to be considered of economic importance.

No citrus orchards or trees could be found sufficiently infested with the fluted scale in southern California to serve for any adequate tests as to the influence of the Argentine ant. The scale occurred

¹ A condition such as this apparently occurs in the case of the fluted scale on Spanish broom in Ventura County, Cal.

² Tucker, E. S. Suppression of the Cottony Cushion Scale in Louisiana. La. Agr. Exp. Sta. Bul. 145. 1914

³ Quayle, H. J. Citrus Fruit Insects. Cal. Agr. Exp. Sta. Bul. 214, p. 470. 1911.

very scatteringly and, as a rule, was parasitized or had been destroyed by its natural enemies. This was true in orchards overrun by ants and in orchards free from ants, indicating, at least, that so far in southern California the helpful influence of the ant, if any, in relation to this scale insect has not overcome the effective control of the scale by its natural enemies.

Aside from the well-known effectiveness of the Australian lady-beetle (*Novius cardinalis* Muls.), this control seems to be due, in Los Angeles County, chiefly to the parasitic fly *Cryptochaetum monophlebi* Skuse, aided, however, by hymenopterous parasites and the larvæ of lacewing flies.

INFLUENCE OF THE ANT ON ABUNDANCE OF THE BLACK SCALE IN LOUISIANA.

As already stated, the black scale (*Saissetia oleae* Bern.) does not yet occur in the orange groves proper of Louisiana, and, therefore, as with the fluted scale, no extensive tree-banding experiments could be conducted in this State during the seasons 1913 to 1915 to determine the effect of ant attendance on its abundance.

The black scale occurred in moderate numbers on oleander in New Orleans, and from these trees was transferred and colonized on young orange trees and an experiment of this nature attempted. The progeny of the colonized scales made an equally good start on both ant-free and ant-invaded orange trees. Nevertheless, the scales failed to reach maturity in a single instance, even where constantly attended by ants, and although they decreased a trifle more slowly where attended than where not attended by ants, all scales had disappeared from both banded and nonbanded trees within six weeks from the starting of the experiment.

INFLUENCE OF THE ANT ON ABUNDANCE OF THE BLACK SCALE IN CALIFORNIA.

The black scale has been rated as the most economically important of the citrus scales in California,¹ where it is generally controlled by fumigation. The observations on the relation of the ant to this scale were made in orchards in which fumigation had been temporarily neglected. In an experiment in which five scale-infested orange trees were banded to exclude ants in April, and a similar five left accessible to them, the amount of scale infestation remained practically equal on both sets of trees throughout the summer, from April to September.

In other words, after excluding the ants from five of these trees for a period of nearly five months but little difference in the amount of black-scale infestation or in quantity of sooty mold could be detected between them and five similar trees very heavily invaded by

¹ Quayle, H. J., op. cit., p. 445.

ants during the entire period. What difference existed was unfavorable to the view that the ants cause greater increase of the black scales. None of the trees had been fumigated since 1914.

In another experiment two more black-scale infested trees were banded against ants in June and two similar trees left accessible to them. These trees had not been fumigated for three years. As in the case of the first experiment, the amount of black-scale infestation remained practically equal on both banded and nonbanded trees throughout the remainder of the season.

Sometimes there is a greater amount of black-scale infestation on trees where there are no ants than on other trees of the same age and condition overrun by ants. Thus, in a block of orange trees not fumigated for two years more than half the fruit on a number of the trees on which there were no ants was scaly, while on a number of trees overrun by ants less than one-fourth of it was scaly. In this case the greatest scale infestation occurred on trees located next to older and heavily infested ones from which the scales had come by the usual means of dissemination, but there was no indication that the ants caused an increase of the scales on the trees on which they occurred.

In various orchards in Los Angeles and Ventura Counties, in which there were no ants and in which fumigation had been neglected for from two to four years, the black-scale infestation was quite as severe as is ever seen where the ants are present. In fact, in order to keep the black scale from reaching injurious numbers it has been found necessary every year to fumigate some orchards in which there were no Argentine ants and very few of other kinds. Sometimes a second fumigation is needed in the same season because of rapid reinfestation by what is called an offhatch, or an extra generation of scales, caused by their more rapid development on especially suitable trees.

It is evident, therefore, that the black scale in southern California is capable of reaching a very injurious degree of infestation in a single season, regardless of whether ants are present or not. Its natural enemies are not sufficiently numerous to prevent severe infestation, even though there is no interference from ants. The effect of the ant in accelerating the increase of this scale is therefore of little practical importance and does not compare with its importance as affecting the mealybugs.

INFLUENCE OF THE ANT ON ABUNDANCE OF THE SOFT BROWN SCALE IN LOUISIANA.

As was the case with the black scale, it was impossible to find a sufficient number of orange trees in Louisiana heavily infested with the soft brown scale (*Coccus hesperidum* L.) to conduct extensive

experiments to determine the effect of the ants. In a test conducted upon young orange trees colonized with the scales, two of the trees, on which there were 5,425 and 334 young scales, respectively, were banded to exclude ants, while a third, on which there were 3,100 scales, was left accessible to the ants for comparison. The number of scales gradually diminished on all the trees, accompanied by a corresponding increase of parasitized scale remains, until within two months from the time of starting the experiment practically all had been destroyed.

The destruction of these scales was caused almost exclusively by parasites, the percentage of parasitized scales increasing, with slight fluctuations, at the same rate on the tree frequented by ants as on the two trees from which ants were excluded. There was nothing in the condition of the trees or in their suitability as a food plant of this scale to prevent the scales from thriving, as was shown by the fact that a few sound scales which had secured perfect shelter from parasites remained on the trees as late as October, three and one-half months after all those not sheltered had been destroyed.

It was plainly seen in this experiment, and many other observations bear out this conclusion, that the internal parasites are the most effective enemies of the soft brown scale in Louisiana and that the Argentine ant does not extensively prevent the work of these insects. A considerable number of adult parasites were seen on these trees during the examinations, and fully as many on the ant-invaded trees as on the noninvaded ones. Two species of chalcids,¹ viz, *Eupelmus coccidis* Gir. and *Coccophagus coccidis* Gir., were reared from ant-attended soft brown scales in Louisiana.

While an orange tree occasionally would be found in Louisiana with one or more small branches very heavily infested with the soft brown scale, assiduously attended by the ants, the worst infestations that came to notice were on plants other than citrus. For example, in an orange grove at Buras, where this scale was present in small numbers and scattered on orange trees, one limb of a rosebush was found infested so severely that in a space 1 foot long on a branch about one-eighth inch in diameter there were 1,440 scales.

Large groups of this sort sometimes are found in which there is very little evidence of parasitism, but usually from 2 to 60 per cent or more of all the scales occurring in such groups either contain the parasites or show their exit holes.

The soft brown scale undoubtedly is held in check in Louisiana orange groves, regardless of whether ants are present or not, by its natural enemies and particularly by the internal parasites.

¹ Identified by Mr. A. A. Girault.

INFLUENCE OF THE ANT ON ABUNDANCE OF THE SOFT BROWN SCALE IN CALIFORNIA.

There was no opportunity during the season of 1916 to study the effect of the ants on abundance of the soft brown scale in the orange groves of southern California because of the scarcity of the scales. Larger groups of this scale occur on various ornamentals where attended by the ants than where there are no ants, and its abundance on camphor, bottle, and pepper trees and many others along some of the streets of Pasadena where the Argentine ant occurs makes it appear that the ant has the effect of greatly increasing the infestations there. Neither the soft brown scale nor the closely related citricola scale¹ occurred in any greater number in the ant-invaded orange groves of Los Angeles County than in those where the ant did not occur. In Riverside County, on the contrary, large groups of the soft brown scale were found more easily in the ant-invaded than in the noninvaded orchards. Quayle² has noted that the soft brown scale becomes especially serious under the influence of the ant in that county. Several orchards were mentioned by Mr. D. D. Sharp, Riverside County horticultural commissioner, in which the soft brown scale had become so numerous as a result of attendance by the ant as to attract general attention. In one of the most severely ant-infested orchards, however, which it was said had not been fumigated for several years, there was a large parasitization of the soft brown scale, as high as 82 per cent of them being found destroyed by parasites in a group under heavy ant attendance.

It appears, therefore, that the Argentine ant may afford enough protection to the soft brown scale at times on certain trees or in certain localities to cause the formation of larger groups than is customary and retard the destruction of the insect by its natural enemies. This effect has not, however, been marked enough either in California or Louisiana to change the rank of the scale as a citrus pest of merely minor importance. This is due to the fact that internal parasites and not predacious enemies are the chief factor in the natural control of the scale.

RELATIONS WITH THE CITRUS WHITE FLY.³

THE ANT AS AN ENEMY OF THE WHITE FLY.

The only direct relation which the Argentine ant bears to the citrus white fly is that of predator. The first knowledge of this fact came as a result of observations made in an orange grove at Happy Jack, La., in April, 1913. At that time the prevailing belief, which

¹ *Coccus citricola* Campbell.

² Quayle, H. J. In Jour. Econ. Ent., v. 9, p. 472. 1916.

³ The citrus white fly (*Dialeurodes citri* Ashm.). The cloudy-winged white fly (*Dialeurodes citrifolii* Morgan) also occurs in Louisiana, but is greatly outnumbered by the first-named species.

was shared by the writer, was that the ants fostered the white fly for its excretions, and when many ants were seen carrying adult white flies down an orange tree it was taken as evidence that they were transferring this pest to other trees and colonizing them thereon. As a principal occupation of the ants on nearly every tree was carrying white flies, however, and the reason for carrying only adults was not clear, the opportunity was taken to observe this work more closely.

It was noticed that comparatively few ants were carrying white flies up the trunk, but that a very large majority, certainly over 95 per cent, were carrying them down only. If the ants were establishing the white flies on other trees, it seemed that at least there should be somewhere near the same proportion carrying them up as were carrying them down the trees. Many of the ants therefore were traced as they carried the insects up and down the trees. Invariably those going up trees were traced to some cranny, where they poised in the dark for a rest or to avoid a breeze, or they would go up a short distance and then turn and go down again. Invariably those going down the tree were traced to the entrance to an underground nest, where they disappeared from view. Some of these entrances were directly at the base of the tree, but digging out such tunnels proved that the ants were not nesting about the roots of the trees or other plants on which the white fly might feed. It also disclosed the complete absence of underground colonies of living white flies and the presence of piles of dead remains of adults in the ant tunnels.

The next step was to examine white flies carried by the ants to determine whether they were living or dead. Some of them were living, and a good many more were dead, but the most important discovery was that a very large majority still had their wings crumpled, as they are immediately after emergence from the pupa case, showing that they were captured just as they emerged.

The percentage of white flies which the ants destroy must vary widely in the various groves at different times, and is probably never high enough to be of great economic importance. In a series of ten examinations to determine what proportion of the ants descending orange and privet trees with forage had captured white flies, the following data were gathered on the subject:

All the ants passing a point on the trunk going down the tree in a certain length of time, usually from 10 minutes to a half hour, were counted and classified as to whether or not they carried forage. Those carrying liquid forage could be distinguished by the distended gaster. The kinds of insects carried were noted without disturbing the ants where possible; otherwise the prey was collected. In

these examinations it was found that from as low as 0.7 per cent to as high as 54 per cent of the ants which had any kind of forage carried white flies. Other of the lower percentages were 0.9 per cent, 3.1 per cent, 3.2 per cent, and 13.8 per cent; while other higher percentages were 21 per cent, 21.7 per cent, 34.7 per cent, and 38.4 per cent. Most of these examinations were made at times when the foraging was not too heavy, so that the ants could be counted without danger of confusion, and the number of ants carrying white flies was often too large to count. The percentage of ants with forage in their possession in these examinations ranged from 16.1 per cent to 75.8 per cent.

The above phenomena, which were observed many times on citrus and other plants every season spent in Louisiana, always may be seen during the emergence periods of the white flies in orange groves invaded by the ant. At times the ants with their captives are so numerous that the most casual glance will discover them as they go wavering down the trunks with the white-fly wings spread above their heads like diminutive sails. At times, when such a caravan is suddenly struck by a light breeze, the little sails will scatter in every direction as the ants hunt for temporary shelter to prevent being blown out of their course. The only possible direct part played by the ant in its relations with the adult citrus white fly in Louisiana is that of predacious enemy.

RELATIONS OF THE ANT WITH IMMATURE STAGES OF THE WHITE FLY.

Investigation of the behavior of the ants toward larvæ and pupæ of the citrus white fly brought out the fact that, although they hover about these immature stages more or less, they do not palpate the larvæ or directly obtain their excretion, but that they watch over the pupæ solely for the purpose of capturing the emerging adult insects. Although the ants do not capture living white-fly larvæ, and only a comparatively few pupæ, they are occasionally seen carrying the latter. The pupæ taken are nearly always those in which the transformation to the adult is almost completed, the ants becoming impatient at waiting for the adult to appear or being impelled to attack by its attempts to extricate itself from the puparium. In some instances as many as 8.7 per cent of the white flies taken from the ants have been pupæ, but this proportion is doubtless above the average.

When most of the white flies on a heavily infested tree overrun with ants are in the larva stage the ants never are found in attendance in considerable numbers on the worst infested leaves. The ants have been seen to lick the leaf surface in the vicinity of white-fly larvæ and they undoubtedly secure a certain amount of white-fly

excretion in this secondary manner, especially when other food is scarce in the trees. If any large proportion of the white-fly excretion were taken by the ants, however, the sooty-mold fungus would be by so much the less prevalent in ant-invaded trees; this, however, is not the case. The ants do prevent to a very large extent the collection of excretory matter and the formation of sooty mold after mealybugs, even inducing such rapid excretion in certain young stages that the mealybug is unable to form the woolly covering, its body remaining almost naked and pink.

EFFECT OF THE ANT ON ABUNDANCE OF THE WHITE FLY.

An experiment to determine the effect of the ants on abundance of white flies was started on April 25, 1914, a young orange tree with 838 white-fly eggs being banded to exclude ants and a similar tree with 1,474 eggs kept accessible to ants for comparison. The percentages of young stages of the white fly dying from unknown causes and the quantity of new growth on the two trees were noted at every examination to make sure that the difference in white-fly infestation was not due to varying food conditions.

On May 13 there were on the tree from which ants were excluded 949 sound and 113 dead larvæ and pupæ and 189 unhatched eggs; on the tree that was accessible to ants there were 434 sound and 109 dead larvæ and pupæ and 112 living eggs. Between May 13 and June 12 the nonbanded tree was merely kept under surveillance by scouting ants, but on June 12 white-fly emergence was at its height and the ants had formed a heavy trail into the tree, where they were capturing the emerging adults. Living white-fly larvæ and pupæ were comparatively scarce and about equal in number on both trees. The remarkable thing was, however, that on the ant-invaded tree there were 167 empty pupa cases from which white flies had emerged and only 8 of the adult white flies, whereas on that from which ants were excluded there were 151 empty pupa cases and 130 of the emerged adults. In other words, the nonbanded tree was swarming with ants, some of which were carrying adults, and only 4.51 per cent of the emerged adults remained on the tree, whereas on the tree from which ants were excluded almost the same amount of emergence had occurred and 86 per cent of all the emerged white flies were still on the leaves.

From June 12 to about the middle of August the white flies increased faster on the tree from which the ants were excluded than on the other. On July 1 there were 5,435 living young on the former and only 1,919 on the latter. The percentage of dead was practically the same on both, being 12.9 per cent of all young on

the tree from which ants were excluded and 10.4 per cent on the tree to which they had access.

On July 17 the banded tree still led in white-fly infestation, there being 3,711 living young on this tree to 1,497 on the ant-patrolled tree, and by the 13th of August white-fly eggs, larvæ, and pupæ were too numerous on both plants to count. This final heavy infestation of both trees was expected, as it was improbable that complete white-fly control in the height of its breeding period could be accomplished by the ant.

The relations of the ants to emerging white flies brought out in the foregoing experiment led to similar observations on other trees. On June 12, at the height of a white-fly emergence period, two more trees from which ants were excluded and two on which they were present were inspected. On the first two trees there were 431 empty pupa cases from which white flies had emerged, and 369 adult white flies, or 85.6 per cent of all which had emerged, still remained upon the trees. On the ant-invaded trees there were 600 empty pupa cases with emergence slits, but only 36 of the white flies, or 6 per cent of the emergence, remained upon the trees.

These observations indicate that the principal direct effect of the Argentine ant upon the citrus white fly in Louisiana is to destroy a varying proportion of them, thus entitling this ant to be called a white-fly enemy.

RELATIONS WITH APHIDS.

The relation of the Argentine ant to aphids has been observed principally on the orange-infesting species, chief of which is *Aphis gossypii* Glov. In Louisiana, however, certain observations have been made upon the relations of this ant with aphids on loquat, elder, privet, oak, cypress, and certain weeds.

THE ANT AS A PROTECTOR OF APHIDS.

The orange aphid appears in considerable numbers, sometimes very large numbers, on the newer growth early in the spring, often increases throughout April and May, causing some of the leaves to curl, and thereafter rapidly disappears, while a heavy parasitization is indicated by numerous dried skins punctured by the exit holes of the parasites. This condition, which has long existed both in California and in Louisiana, has not been altered materially even in groves and trees overrun by the Argentine ant. In Louisiana it occurs in scattered groups in January and February, often greatly increases in March, and becomes numerous on tender leaves and some of the blossoms in certain orchards during April and May. Even where heavily attended by the ant, however, its natural enemies.

and chiefly the internal parasites, have so reduced it by July or August that it is difficult to find specimens.

The following examples will serve to illustrate the ineffectiveness of the ant against the parasites of the orange aphid: On April 22, 1914, in an orange grove overrun with ants at Happy Jack, La., aphids were very numerous, averaging about 34 per leaf of the worst infested leaves, and undoubtedly would have done much damage had their increase continued long at the same rate. Even at this time, however, the aphid shells punctured by parasite exit holes indicated a parasitization of 29.7 per cent. Three hymenopterous parasites seen ovipositing in the aphids among the ants were watched until they had parasitized nearly every aphid on their respective leaves. While ovipositing in the aphids these little insects nimbly avoided the ants without flying. On May 15 living aphids could be found on these trees only with difficulty. In the meantime, too, many of the parasitized remains previously seen had been blown from the leaves, so that there was very little evidence that aphids had ever been numerous there.

On April 28, 1915, 15 per cent of the ant-attended aphids in an orange grove at Ollie, La., had been parasitized, but living aphids were still rather numerous, averaging 20 per leaf on those leaves examined. By May 12 the aphid infestation in this grove had decreased more than 50 per cent, and 49 per cent of the remaining aphids were parasitized. On May 27 an examination of twenty-five times as many suitable leaves as before revealed an average of only about two aphids per leaf, and 92.6 per cent of these were parasitized. The foregoing observations are merely examples of what may be seen annually in almost any grove in Louisiana in which ants and aphids occur.

At Alhambra, Cal., early in April, 1916, a trail of ants was found leading to flourishing small colonies of aphids on the new sprouts of an orange tree that had been cut back about 4 feet from the ground. The aphids were very numerous and not more than one per group showed evidence of parasitism. On April 21 fully half of the aphids had disappeared from this tree and 79.6 per cent of the remainder were parasitized. Ten aphid-feeding lady-beetles (*Hippodamia convergens* Guérin) and a few syrphid-fly larvæ also occurred on the tree.

At Duarte, Cal., 20 young ant-invaded orange trees, badly infested with aphids on the new leaves about the middle of April, were almost completely free from them when examined on May 19. The few aphids remaining alive were being attended by the ants, but not one-tenth of 1 per cent of what had previously been present remained on the trees at this time, and discolored and dried shells with their parasite exit holes were everywhere present.

Again, at Sierra Madre, Cal., on June 16, scattered groups of aphids attended by ants on several trees revealed a parasitization of 92.1 per cent. On one of these trees 14 syrphid larvæ with 1 coccinellid larva and 15 or 20 ants were found working on the same groups of aphids.

The relations of the Argentine ant to an aphid commonly occurring on elder in Louisiana were observed especially because of the exceptional abundance attained by this plant-louse early in the summer and its abundant attendance by the ants. During March and April the aphids become too numerous for the trees to support and thousands fall to the ground, covering the grass under the trees and crawling back up the trunks in large numbers for days at a time. This aphid is progressively destroyed by predacious enemies and especially by parasites, until by the middle of June it invariably has been reduced to an insignificant number, which gather about the bases of the stems and leaves, where the best possible shelter occurs. On April 24, 1914, the comparatively few shells and aphids remaining on one of these trees were counted. There were only 1,667 in all, 529 of which were living, 68.4 per cent being parasitized. The principal parasite concerned was identified by Dr. L. O. Howard as a species of *Aphidencyrthus*.

On March 24, 1914, 9 robust young elder plants in pots were infested with the aphids and placed where the ants could get to them. About a month later, May 7, there were on all plants 2,436 living and apparently sound aphids and 985, or 28.7 per cent, parasitized. All parasitized shells were removed, and, on May 13, 1.18 per cent more aphids, parasitized since the previous examination, were removed, after which ants were excluded from 4 of the plants, on which were 418 sound aphids, and allowed access to the remaining 5, on which were 535 aphids.

On June 3 only 47 living aphids remained on the ant-free plants, but 119 were on the ant-invaded plants; and by June 16, at which time most all the aphids had disappeared from the large elder trees thereabouts, not a living aphid was left on any of the little plants.

In another experiment 2 robust elder plants were colonized with aphids on March 24. One plant was given 187 aphids and placed in a large trail of ants, and the other was given 185 aphids and placed where the ants could not get to it. By April 8 there were 3,194 living, apparently sound aphids on the ant-attended plant, an increase in 15 days of 1,708 per cent; and on the ant-excluded plant there were 2,514, an increase of 1,364 per cent. The more rapid rate of increase on the ant-attended plant seemingly was due to the activities of the ant, other factors being apparently the same in both cases. The number of living sound aphids soon began to decrease on both

plants, and as in the beginning it had increased more slowly on the ant-free plant, it now decreased more rapidly on that plant.

On April 25 the number of aphids on the ant-attended plant had decreased to 2,043, on the ant-free plant to 802, and, from that date on the decrease continued as follows: On the ant-attended plant there remained, on May 6, 182 aphids; on May 20, 18; on June 3, 23; while on the ant-free plant, on May 6, there were only 52 aphids, and on May 20 all had disappeared. The ants, therefore, appeared to give a slight advantage to the aphids up to this time, but by June 16 all had disappeared from both plants, the parasites having won in the struggle for their possession. It is seen therefore that although the ant attends the orange and certain other species of aphids having very efficient internal parasites, it is unable to prevent the destruction of these aphids and cause any noteworthy increase in their number.

TRANSPORTATION OF APHIDS AND COCCIDS.

Although at times nearly 50 per cent of the ants foraging in citrus and some other trees capture insects and carry them down the tree, taking it throughout the season the average is less than 1 per cent. About 8 per cent of the total foraging workers counted in all examinations were engaged in carrying all kinds of insects, but this is, of course, above the average, as counts were made only upon trees where the ants were engaged conspicuously in the transportation of insects. Only a fraction of 1 per cent, viz. 0.5 per cent. of the insects carried by the ants were scales and aphids, and only under exceptional circumstances is the number carried worth considering.

Extended observations on the activity of the ants in transporting scales and aphids have led to the following conclusions:

(1) The ants feed to a slight extent upon the surplus insects when its host scales or aphids are very numerous, upon those that have died from parasitism or some other cause, and upon male scales as fully as their ability to capture them allows.

(2) The ants utilize dead shells of the black and some of the armored scales for the construction of shelters and feed upon the softer by-products and detritus of these scales.

(3) Direct dissemination of orange scales and aphids by the ant is only incidental and is negligible. Indirectly the ants aid in the dissemination of some of these insects by greatly increasing them on particular trees, and from these points of heavy infestation they spread by the usual means.

Some of the facts which lead to the foregoing conclusions are as follows: A large majority of the scales and aphids carried by the

ants are dead. Thus about 94 per cent of the mealybugs taken from the ants were dead or discolored and scarcely able to move, while with the black scales and aphids carried the percentage of dead was still higher. On the other hand, of those insects which do not furnish honeydew to the ants most are alive when taken from their captors. Nearly all captive white flies are alive, as are the psocids, and even such fragile insects as thrips may be handled so lightly by their captors as to remain apparently uninjured. Thus, on one occasion, a thrips dropped by an ant at once started to run, when another ant seized and bit it viciously several times, after which the only sign of life was a twitching of legs and antennæ.

The ants almost always carry their scale and aphid hosts, as well as all other captured insects, to the nest, which is rarely if ever so situated as to afford living conditions to these insects. On rare occasions, in Louisiana, living mealybugs had been found in ant trap-nests, containing only dried straw and manure, but this happened in winter, when the mealybugs left not only the trees where there were ants, but also those in a part of the orchard where no ants occurred, and located on Bermuda grass. The soft scales found in ants' nests almost always have been dead. On one occasion when an exceptionally large number of ants carrying mealybugs down an orange tree could be traced to the nest in the rotting wood, many dead and discolored mealybugs and mealybug particles were found and 80 whole bugs counted. There were only 2 living mealybugs, and these appeared to be diseased, being unable to move except for twitching the legs a little.

The ants carry their host insects in considerable number only when these insects are exceptionally numerous, at which times they are able to supply a great deal more honeydew than the ants actually require. In Louisiana the ant attendance on the black scale and the citrus mealybug was nearly always in greater number than could obtain honeydew from them continuously. In California, however, the black scale, where unchecked by fumigation, becomes very numerous, overflowing the trees and covering them with sooty mold. On such trees the ants carry many scales at times. Thus in one orchard, in which both ants and black scales occurred in exceptionally large numbers, an unusually large number of ants were so engaged. Fortunately for observation, many of the nests to which ants could be traced were in the rotting stubs of cut branches. In these nests the scale phase most readily seen (that is, shells of mature scales) was scattered throughout the ants' galleries. Many nests, with their contents, were removed and examined, and the remains of numerous insects found there, but the black scales, of which there were 118 young stages, all dead, and 97 shells of mature scales, outnumbered

all others. Ants, with scales, also were traced to underground tunnels, which led neither to tree roots nor to any plant roots on which the scales could live.

Aphids, too, are transported only when the infestation is very heavy. The largest numbers carried were upon maple and elder trees, on which aphid infestation persisted somewhat longer than on orange trees because of more rapid parasitism of the orange-infesting species. A great majority of the aphids carried were dead. Since almost all are destroyed by parasites, some undoubtedly contain parasites when taken by the ants, but the number thus destroyed is too small to reduce the effectiveness of these enemies. The destination of the aphids carried was generally the underground nest. Only a very small percentage of the ants carry these insects up tree, and, when traced, these always have gone into one of the ant shelters for rest or, ultimately, retraced their steps down the tree.

Experiments have been tried several times to induce the ants to remove scales and aphids from unsuitable food to a place where they could thrive. As an example of these experiments, about two dozen elderberry stems, very heavily infested with aphids, were on one occasion placed in the midst of thousands of ants at the base of an elderberry tree and examined at intervals thereafter. At the end of an hour aphids were leaving the stems, many were scattered about in the short grass, and a considerable number of others were traveling up the tree trunk. A great majority of the ants paid no attention to these wanderers, but a few followed and stroked individual aphids while in motion. One such ant, becoming impatient after a few minutes of unrewarded effort, seized an aphid by a leg and pulled it about this way and that for a distance of fully a foot, when it let go and went its way.

Similar experiments were performed with mealybugs, infested stems being cut and placed among numerous ants in pots containing vigorous young orange trees. The ants would attend and stroke these mealybugs indefinitely, but in not a single instance did one transport a mealybug from a dying stem to the flourishing growth of the young orange tree. Many of the mealybugs would wander off the dry stems, and some of them would find their own way sooner or later into the healthy tree.

On one occasion, in California, a good opportunity was presented to the ants to assist mealybugs to regain trees from which they had been knocked by spraying with water under high pressure. The ant invasion was from "very heavy" to "extremely heavy" in about 70 per cent of the trees examined, the remainder having "light" or "very light" trails. Some of the mealybugs hit by the water were

knocked from one part of the tree to another, often landing on the trunk or larger branches. From 10 to 17 trees were examined each time, and in all these inspections only 8 ants were found carrying mealybugs, 7 of which were dead. In from one-half to 3 hours after spraying an average of 3 mealybugs per tree were crawling up the trunk; 18 hours after spraying the number had increased to 5 per tree average; at about 48 hours after spraying there was on an average only 1 mealybug returning to every 4 trees. Certainly the ants did not assist to any appreciable extent in their return.

The ants occasionally become impatient with aphids and scales that fail to excrete and seize these insects, just as at times they become impatient at waiting for an adult white fly to emerge and seize the pupa. The pile of mealybug remains found in the tree nest previously referred to indicates that the mealybugs were utilized as flesh food. There is little doubt that if sufficient time and pains were taken the ants actually might be observed eating occasional aphids and scale insects.

RELATIONS WITH INSECT ENEMIES OF SCALES AND APHIDS.

EXTENT OF CAPTURE OF PREDATORY AND PARASITIC INSECTS.

The ants are antagonistic to all the predacious and parasitic insect enemies of coccids and aphids, but not more so than they are to all other insects which do not furnish them with honeydew. The ants are habitually carnivorous and view all other insects, excepting perhaps some of the myrmecophiles, either as their cattle, furnishing them with liquid food, or as their prey, useful as flesh food. Although the ants take every opportunity to capture both predators and parasites of the scales and plant-lice, the number of this class of insects captured is very small. The close and constant attendance of the ants at scales and aphids, by preventing free oviposition and feeding of the natural enemies, accounts mainly for the ants' effectiveness as protectors of these pests, although the ants do feed to some extent upon eggs of certain scale predators.

A large number of insects have been taken from the ant and identified, and only 0.72 per cent of all the insects carried have been predatory on species attended by the ants. These consisted of larvae of the Lencopidae, the brown lacewings, Syrphidae, and Lepidoptera, the last very rarely, indeed. It is seen, therefore, that the number of predatory enemies of the soft scales and aphids which the ant is able to capture is insignificant. The number of internal parasites captured is still smaller, being only one one-hundredth of 1 per cent of the insects taken from the ants.

MEANS OF DEFENSE OF THE LACEWING INSECTS.

The following observation will illustrate the methods of defense of certain of the predatory enemies of soft scales and aphids. The larvæ of the lacewing flies when attacked emit a fluid from the tip of the abdomen which, though so small in amount that it can scarcely be seen, strongly affects the ants. The larvæ will avoid the ants if possible by keeping out of their trails when moving, and when feeding upon mealybugs take up a position under the groups, where they are protected by their prey. On a tree in which many cocoons of *Chrysopa californica* Coq. occurred and which was overrun with ants a larva of the *Chrysopa* was seen crawling up the trunk on the opposite side from the ant trails. The larva was teased over into the midst of the ants, with the following result: An ant seized it by a foreleg, when it brought the tip of its abdomen forward and touched the ant, which then dropped to the ground. A second ant ran up, but as the chrysopid brought the tip of the abdomen forward, backed away, and the larva resumed its journey. Another ant took hold and, receiving the same treatment, backed hurriedly away in a circle, frantically brushing its head with the forefeet. Four ants then made a combined attack. The larva deliberately waited until they had a good hold, probably to be sure of its mark and conserve the secretion, when it touched them, and they acted precisely as had the preceding one. All these ants soon ceased to move and acted as if very sick. In the meantime the chrysopid passed out of the ant trail and proceeded up the tree. The larvæ of the brown lacewings defend themselves in precisely the same manner, emitting a minute globule of bright amber to red fluid that is evidently injurious to the ants.

MEANS OF DEFENSE OF THE LADY-BEETLES.

The larvæ of various coccinellids are protected by a covering of spines or of cottony excretion and by a thick yellowish material exuded from pores situated along the margins and dorsum of the body. Ants many times have been seen attempting to seize larvæ of the mealybug-feeding species *Hyperaspis lateralis* Muls., but not in a single instance did they succeed in capturing one. This larva, when feeding in the midst of mealybugs, usually remains perfectly motionless and does not attract the attention of the ants. When moving and attacked by them it flattens first one side to the surface, and, if attacked by several ants at once, it flattens down all around, leaving only the cottony filaments exposed. Sometimes the ants then will pull out masses of this cotton, and on one occasion they were

observed to pull out so much of it that the thorax of the lady-beetle was made completely bare. In spite of this the object of the attack was able to escape. At another time several ants were attacking one of these larvæ at once and each of them pulled out a mass of cotton from time to time. It soon was seen that some of them were unable to loosen the material from the jaws and were thus kept out of the contest.

The larvæ of such species as *Coccinella californica* Coq. and *Hippodamia convergens* Guér. rely principally upon immobility, flattening out, and their spiny covering for protection. The larva of *Rhizobius ventralis* Erichs. depends upon immobility, its natural flatness of body, and, in the presence of the black scale, which is its preferred food insect, the honeydew from the scales collects in the setæ on its body and becomes coated with sooty mold, blending to some extent with the sooty, sirupy leaf surface. The final emergency protection of all these larvæ, after having exhausted the defensive means of protection, is the so-called "reflex bleeding," or excretion, of a poisonous, repellent substance from the glands of the body. This occurs whenever the larva is roughly handled or there is danger of enemies actually destroying it.

The adult coccinellids defend themselves principally by flattening out, thus presenting the wing covers to the enemy, and by kicking. The kick consists of a sharp jerk of the leg by which the ant, threatening to seize it, is prevented from so doing. The ants often have been observed trying to capture adult lady-beetles, but never have they been seen to succeed. A single instance will illustrate the method of defense: On an orange tree overrun by the ants and also harboring numerous lady-beetles (*Coccinella californica*), one of the lady-beetles was seen traveling up the trunk in the trail of ants. Most of the ants were passing hurriedly by, swerving aside to avoid contact with it, but one ant was following and trying to seize one of its legs. This ant moved from side to side of the coccinellid, its jaws wide open, rushing it whenever there appeared to be an opportunity. Every time the ant would attempt to take hold, however, the lady-beetle would either give a quick snap of its leg or would lower the body on that side. This ant finally was joined by a second, and both tried for 10 or 15 minutes, without success, to capture the insect. There seems to be evidence that adult coccinellids also sometimes secrete a repellent fluid in very small amounts when attacked by ants, for the ants often back suddenly away on coming into contact with them. As a last resort adult coccinellids also have recourse to "bleeding," which seems capable of repelling many ants at once and even much larger enemies.

Lady-beetles often occur in large numbers on trees overrun by ants. This was commonly the case in Louisiana with a minute, shiny black lady-beetle, *Microweisla misella* Lec., which occurs in large numbers on trunk and branches of orange trees at certain times of the year. This insect apparently feeds upon eggs and young of the chaff and purple scales and is entirely oblivious of the ants. The same is true of the large twice-stabbed lady-beetle, *Chilocorus bivulnerus* Muls., which often occurs in large numbers in all stages upon heavily ant-invaded trees.

In California, large numbers of adult *Hippodamia convergens* and *Coccinella californica* and all stages of the black lady-beetle (*Rhizobius ventralis*) occur at times on orange trees overrun by ants. On one occasion more than 1,000 adults of the first two and the ashy gray lady-beetle (*Olla abdominalis* Say), all of which feed extensively on the excretions of the black scale, were counted upon 10 trees on which the ants were exceptionally numerous. Again, more than 60 of the black lady-beetles were found upon each of a number of young orange trees overrun by ants. A certain click-beetle, *Limonius subauratus* Lec.,¹ which feeds upon this excretion, is also fearless of the ants.

MEANS OF DEFENSE OF THE PREDACIOUS PYRALIDAE.

The principal means of defense of the larvæ of the predacious Lepidoptera which feed upon soft scales and mealybugs consists in moving the body rapidly from side to side like the cracking of a whip. The larva of *Laetilia coccidivora* Comst., however, protects itself chiefly by means of a tubular web which it spins over itself and its prey and through which ants can not pass. The nearly mature larvæ are protected rather effectively also by the spines on their bodies, and several times have been seen moving among numerous ants, apparently hunting for a place to pupate, without being molested.

MEANS OF DEFENSE OF THE SYRPHIDAE.

The larvæ of aphid and mealybug feeding syrphids also often are found on the leaves and fruit among the ants. The ants, though once or twice they have been found with very young larvæ of an unidentified species of syrphid in their possession, apparently never disturb them under ordinary conditions. The immobility and the spines of those species which have been observed working among aphids and mealybugs among ants appear to protect them adequately from the ants.

¹ Identified by Mr. J. A. Hyslop.

INTERFERENCE OF ANTS WITH THE WORK OF PREDACIOUS INSECTS.

Although the ants are unable to capture in more than insignificant numbers the insects predatory on the soft scales of citrus, to a considerable extent they do interfere with their work of destroying scales, as has already been indicated. This is particularly true of those scales which occur in groups, such as the citrus mealybug and soft brown and some other scales, the predators being unable to oviposit in groups closely attended by the ants. Under normal conditions the citrus mealybug, in Los Angeles County, Cal., is held in almost complete control by its predacious enemies, chief of which are some three or four species of lady-beetles, the brown and green lacewings, and at least three kinds of predacious flies.¹ Rearings of enemies from a number of large batches of mealybug material collected among the ants at intervals from April to September, 1916, from scattered localities in Los Angeles County gave 71.8 per cent external feeders and 28.1 per cent parasites.

Against the internal parasites, however, the ants appear to be much less effective, as has already been indicated. Of the internal parasites reared from citrus mealybugs in California by the writer, only 9.7 per cent are known to be primary parasites of the mealybugs.

NESTS AND PROTECTIVE STRUCTURES OF THE ANT.

LOCATION AND PURPOSE OF THE NEST PROPER.

The Argentine ant, which is very ingenious at construction, builds its nest to meet the requirements of a comparatively few simple needs, a primary one of which is darkness. Aside from any special aversion which the ant may have to light, it seeks the darkness for safety, and it is only in the dark that the workers ever rest "off guard." The queens, especially the older ones, spend nearly all their time where the darkness is greatest, and when moving in the trails of the foragers, which they frequently do, invariably pass rapidly from shelter to shelter, spending as little time as possible in the open places. The ants never permit their young to remain in the light for long at a time, and both they and the great mass of the queens always are found in the darkest, most obscure parts of the nest.

Another requirement of the ant is a proper regulation of temperature and moisture to suit its young and itself. In exceptionally dry weather, such as often occurs in Louisiana from February to April or May, and in California throughout every summer, the nest will

¹ The natural enemies of the mealybugs of citrus in southern California are being studied by Mr. R. S. Woglum and are referred to here only in a general way, as necessary to show their relationships to the Argentine ant.

be tunneled into the ground. The depth will depend upon how far it is necessary to go to find the needed amount of moisture. It is in the underground nest also that the most comfortable temperature can be found, both in summer when it is very hot and in winter when it is very cold. In the cities the walls of buildings often are utilized, the ants taking advantage of the artificial warmth and shelter afforded. In rainy weather, when the soil is very damp, the underground nest will be abandoned for a location above ground, in buildings, trees, piles of dry weeds, piles of lumber, etc., and under almost any kind of shelter. When the ants are caught in the ground by a sudden rain, in situations where there are no convenient trees, buildings, or other shelter, "sheds" are constructed out of particles of soil and trash along the surface of the ground. These sheds are sometimes very large and are elaborately tunneled into galleries and pavilions. They dry out much more rapidly than the packed soil of the ground, and the young are kept in them until the ground again becomes dry.

OFFSHOOT NESTS AND RUNWAYS.

The ants habitually construct temporary quarters and utilize natural shelters along the foraging trail, especially if the food supply is distant from the nest, as places in which to rest, secluded from light, heat, and wind, and in which wandering queens may hide.

If the food supply is large, attracting many ants for a long period, the ants gradually construct runways, or series of shelters, between the nest and the food source, tunneling them in the ground or building them up of particles of soil and trash, according to circumstances. As these structures are built toward the sources of food and the queens are more or less constantly traveling in the trails of the foragers, it is in this direction that the colony expands. Whenever one of these wandering queens finds a suitably dark and secluded spot along the trail she makes her abode there permanently, deposits eggs, and starts a secondary colony. Queens, eggs, and young occur almost constantly in the larger, more secluded shelters along the foraging trails. This is the most important means of local spread of the colony.

A good illustration of the formation of offshoot nests in the ground occurred in the field poisoning tests at New Orleans. A supply of poisoned sirup kept near a fig tree for several months in 1913 attracted ants from three colonies in turn, all of which finally deserted the neighborhood. On October 2 workers from a fourth colony, nesting in an outbuilding 72 feet distant, arrived, and by October 8 the file of ants from nest to jar had increased enormously.

The ants soon began tunneling into the ground at short intervals along the entire course of the trail, and by October 15 these shafts were numerous. The foragers still followed the original trail along the surface of the ground, but could no longer be traced for its entire length, as they were continually disappearing into the tunnels. Queens gradually separated from the original colony and took up their abode in the tunnels, until finally there was a string of small colonies all along the trail from mother colony to sirup. The original purpose of the tunnels doubtless was to protect the workers from light and heat while they rested from their labors, but the queens found them well adapted for nesting purposes.

SHELTER STRUCTURES, OR "COW SHEDS."

In the trees the ants invariably utilize such natural shelters as cracks and depressions in the bark, abandoned tunnels of borers, the space between touching leaves and fruits, etc., often further excluding light by piling particles of trash along the edges of cracks and walling in the space between nearly touching leaves, fruits, and branches. A portion of the ants foraging in trees almost invariably may be seen retracing their steps up the tree, carrying either liquid forage or prey with them. If traced, these ants usually will be found seeking a rest in the nearest shelter of the sort mentioned. Sometimes, while resting, their forage is deposited nearby and occasionally thereafter forgotten; at other times it is held indefinitely in the jaws.

The erection of the so-called "cow sheds" over scale insects and aphids is a further extension of this habit of building shelters in which the worker ants can rest. The number of ants attending aphid and coccid groups is almost always greater than can secure honeydew continuously. Some of them, therefore, always must be waiting until their hosts have a fresh supply ready. During this period of waiting and unrequited solicitation the "cow sheds" serve the usual ant-protective purpose. These structures, of course, may protect from enemies the particular insects covered by them, but, even if this protection were absolute, no great number would benefit by it, because comparatively so few are covered. The occasional occurrence of parasitized remains of scales under these "cow sheds" indicates, furthermore, that the protection afforded even those comparatively few scales is often faulty.

On orange trees badly infested by the black scale shelter structures sometimes are found over groups of mealybugs, and in this case their most important function happens to be protection of the ants and mealybugs against the honeydew of the scale and its accompanying

sooty and green mold. Again, it seems to be primarily the ants that are protected, as they await the excretion from the mealybugs.

Perhaps the clearest proof that these shelters are built mainly in response to the needs of resting worker ants is the fact that under certain circumstances they will be built on the tables supporting artificial formicaries, where no scales or aphids occur. Six formicaries of the Janet type were kept on small tables set in pans of oil (see Pl. IV). Food, poisoned sirup, and water were placed on the tables outside the formicaries. When sick from a poison, the ants are very eager for water with which, perhaps, to wash out the crops, and numerous sick ants constantly hung about the water plate. Whenever sufficient trash was allowed them they would build a shelter tent from the edge of the formicary to that of the water dish, and this tent always would be full of ants regurgitating the poison and cleaning each other's mouth parts.

THE HABIT OF BURYING NOXIOUS SUBSTANCES.

Another activity of the ant somewhat along this line is the habit of piling *débris* upon noxious substances. On rare occasions they bridge bands of sticky material placed on the tree trunks in this manner. Generally, however, this is done only where the substance is actually injurious. In the field poison tests frequent cases were observed where the shelter-constructing and trash-piling habit merged into one. When foraging at the poison jars it was of common occurrence for the ants to construct out of particles of soft soil elaborate shelters about the sides of the jars, and sometimes completely over them. (Pl. I.) As they learned the effects of the sirup they often would deposit more and more particles on the sponge within the jar and finally fill the entrance hole completely. In one case, for example, they partly covered the sponge and filled the entrance to one of the jars nine times in the course of several months. In an experiment with moth balls placed in a saucer with sirup poured over them, the ants eagerly took the sirup for a week, at the end of which time there were large numbers of dead in the mixture. The ants then became engaged principally in removing the dead. The saucer had been placed on a piece of white crepe paper, and when this accidentally got wet the ants bit out particles of the paper and constructed an elaborate shelter completely around the edge of the saucer. Under this large numbers of workers might be found at all times. As they continued to feed and get poisoned, however, they began piling bits of paper on the moth balls and finally completely covered them with the "confetti."

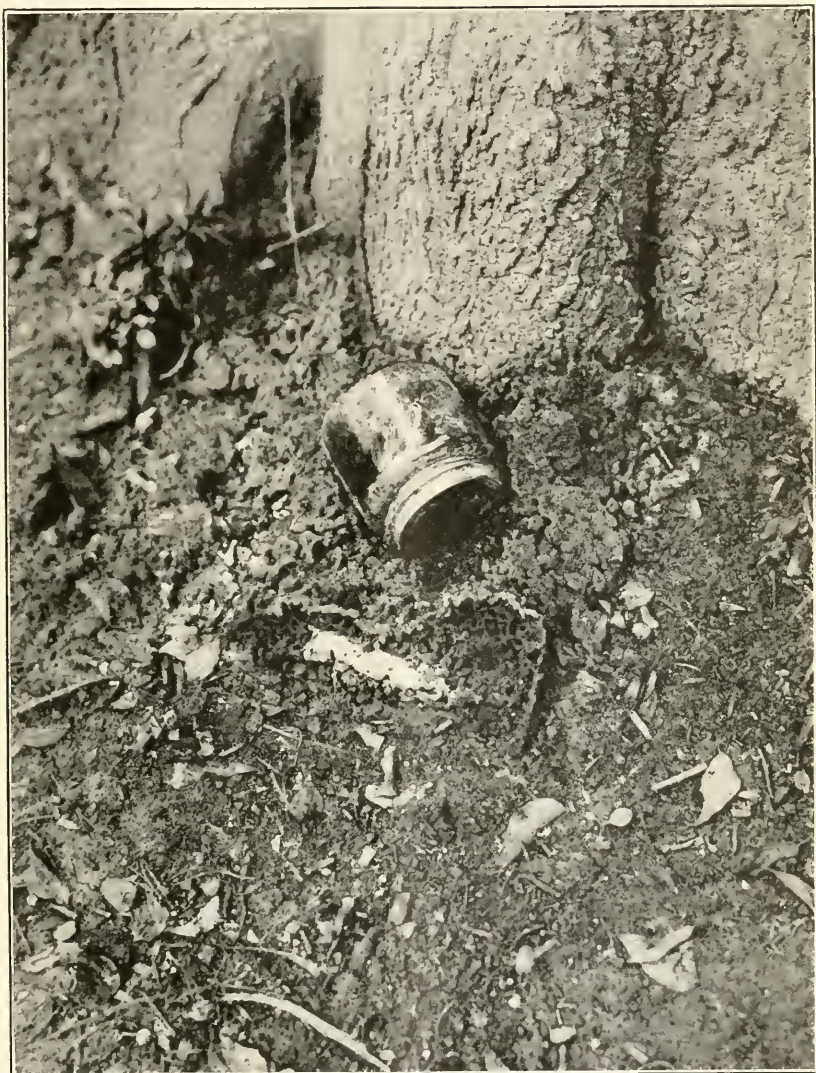
CULTURAL CONDITIONS IN ANT-INVADED VS. ANT-FREE ORANGE GROVES IN LOUISIANA.¹

As already stated, the Argentine ant infests only slightly more than 26 per cent of the orange groves of Louisiana as yet. It was found that 40.7 per cent of the groves that had never had the ants in them were in "poor" condition, while about the same proportion (43.9 per cent) of those that were infested with ants were in good condition. In other words, about 15.4 per cent more of the ant-invaded groves were in "poor" condition than of the noninvaded groves, but this is probably in large part due to the greater neglect of the ant-infested trees because of that infestation, many of the owners becoming discouraged as soon as they found the ants present. A considerable number of groves had been abandoned completely because the ants had gotten into them. A slightly greater reduction in crop had occurred in the groves infested by ants, this reduction being, however, only about 0.22 box per tree greater than in those free from ants. Both the maximum and the last (1914) crops were far below what they should be in both ant-invaded and ant-free orange groves for trees of their age, being in each case less than 1 packed box per tree. In Cameron Parish the large sweet seedling orange trees, in which the Argentine ant does not occur, helped to raise the production average for the groves free from ants, as these trees produce from 5 to 15 boxes each.

Thus it is seen that there is practically no difference between those groves in Louisiana where the ants are present and those where they are not, either in the condition of the trees or in the amount of fruit produced. It is undoubtedly true, however, that where the scale, white-fly, and rust-mite infestations are heavy and no attempt is made to control them the crop will be reduced considerably. The effect of these insects also will be unusually pronounced on trees that are weakened by too close planting, poor drainage, and cultural neglect. The ants appear to have no effect on the rust mite.

That groves completely overrun with the ants and in a badly run-down condition from neglect can be revived and brought back to their normal bearing condition without treating the ants or keeping them from the trees has been demonstrated. The principal features of this work will be related here briefly.

¹ The data on conditions affecting the culture of orange trees in Louisiana were obtained partly by means of questions submitted to the orange growers, partly by personal inspection of the groves, and are complete on about 96 per cent of the groves of the State. Those groves with a large percentage of trees fairly large for their age, symmetrical, with moderately dense foliage, of good color, and bearing an average-sized crop according to local standards, were classed as "good." Those showing a large percentage of under-sized trees, with thin foliage, many dead and dying branches, poor color, lack of growth, and poor crop were classed as "poor."



PROTECTIVE "SHEDS" OF THE ARGENTINE ANT.

Surface shelter of soil particles constructed by the Argentine ant about a poison jar. (Original.)



LOUISIANA BUDDER ORANGE TREE.

Peculiarity of growth of the *Citrus trifoliata* stock, and a comparatively very slight incrustation of lichens. (Original.)

DEMONSTRATION IN IMPROVEMENT OF ANT-INVADDED GROVES IN LOUISIANA.

If preventing the Argentine ant from getting into the orange trees would effect the practical commercial control of the chief armored scales and the white fly in Louisiana, as it does that of the citrus mealybugs in Los Angeles County, Cal., the problem of controlling these insects would be simply one of getting rid of the ants. The natural enemies of the principal pests of Louisiana, however, are unable, even in the absence of ants, to prevent severe infestation. On the other hand, if thorough measures of control were practiced against these insects, there should be no reason to worry about the ants. If the citrus mealybugs in California orange groves were as thoroughly controlled by the regular fumigations as are the armored and black scales, the ants could do only a negligible amount of harm through these insects.

DESCRIPTION OF DEMONSTRATION ORCHARD.

The orchard reclamation work about to be described was conducted on a grove at Ollie, La., practically abandoned, except for the harvesting of the crop. The grove consisted of about 1,055 sweet, naval, mandarin, tangerine, and jaffa trees, a block of 603 of which were treated, the remaining 452 being left as checks. All the trees were very thinly foliated, with small tops, and many of them with multiple trunks. Many of the leaves were yellow and a moderate number of branches were dead. The trees were poorly shaped, and branches were much tangled as a result of bad pruning. Many of the trees were suffering badly with gummosis,¹ some being almost completely girdled about the base of the trunk and larger roots by this disease. (See Pl. III.)

The ant infestation was as heavy as has ever been seen in any orchard. All the trees were very badly infested with chaff, purple, and long scales, the first named being exceptionally numerous. Almost all the fruit had been very badly discolored by the rust mite every year, and, in some years, infestations of the citrus white fly were also severe.

The largest crop ever produced by the full orchard of 1,055 trees was 1,400 boxes, occurring in the year 1911. The crop of the 1914 season had been only 400 boxes; or, in other words, the orchard had suffered a crop reduction of 71.4 per cent in three years.

TREATMENT OF THE ORCHARD.

The demonstration work of improving this grove was started in February, 1915, and continued until interrupted by the hurricane of

¹ Also called "sore shin" disease.

September 29, 1915. The treatment consisted solely of spraying, cultivation, and tree surgery.

Spraying was conducted against the chaff and purple scales, citrus white fly, and rust mite, and for the destruction of the lichens and moss which covered the trees (see Pl. II). The trees were sprayed only three times, the first application, for scales and the white fly, being started February 12; the second, for lichens and moss, May 12; and the third, almost exclusively for scales and rust mite on the fruit, on July 26. Two different brands of paraffin-base lubricating oil made into emulsions containing 1 per cent of the oil and 0.5 per cent of soap were used in the insecticidal work. A commercial lime-sulphur preparation was used in the fungicidal work.

The tree surgery consisted of pruning to improve the shape of the trees, the removal of wood diseased with gummosis, and the cutting back of Jaffa trees preparatory to rebudding. In some cases where the trees branched from the ground into several trunks, those trunks with poor tops which gave no promise of improvement were removed entire. The pruning of smaller branches was very light and consisted in the removal of all dead ones and thinning out of those entangled. All wood infected with gummosis was gouged out with a chisel and mallet and the wounds painted with a mixture of 1 part of creosote to 2 parts of coal tar. This work was all conducted in the spring, from March to June.

The demonstration plat was clean cultivated throughout the season by plowing and cross-plowing, followed by disking both ways of the orchard, four cultivations, March 8, May 12, June 21, and August 26, respectively, being necessary. Close to the trees, where the plow could not reach, the weeds were kept down by hoeing. As the orchard had never before been cross-plowed, a good many fairly large roots were broken in this work, but the trees did not suffer any apparent ill effect from this rough treatment. The drainage ditches surrounding the plat were all deepened about a foot and the weeds choking them removed.

RESULTS OF ORCHARD TREATMENT.

Within three weeks after the application of the lime-sulphur solution most of the lichens with which the trunks and larger branches were coated had fallen off completely, a solution of 30° Baumé, at 1 volume to 50 volumes of water, accomplishing this result.

Owing to the thinness of the trees and scarcity of food in proportion to the number of scales in this orchard, an exceptionally large number of these insects settled on the fruit. A count of the chaff and purple scales on 100 fruits from each of the two blocks on June 23 gave 112 on the sprayed fruits and 3,365 on the unsprayed, rep-

representing a reduction of 96.7 per cent by spraying. By May 27 the leaves of the unsprayed trees had become quite badly infested with white flies. A count of those on 100 leaves picked at random from these trees gave 26,200 larvæ and pupæ, while on an equal number from the sprayed trees there were only 73, a reduction, therefore, of 99.7 per cent.

The rust mite began to appear on the fruit in June, and by the 23d of that month there were 50 to 60 mites per fruit on unsprayed trees, while on the sprayed they could only be found on the row of trees adjoining the unsprayed block and then only to the number of 10 per fruit.

On August 5, after the second insecticidal application, examination of 100 fruits on the sprayed trees gave 987 scales, or an average of about 9 per fruit, and 89 rust mites, the latter being so scarce that they were difficult to find. The unsprayed fruits were so badly infested that scales could be counted in the time available on only 10 fruits, on which there were 6,982, and the rust mites were quite too numerous to count. Fully 75 per cent of the unsprayed fruit had by that date become discolored by the rust mites.

By September the trees in the experimental block had responded beautifully to the treatment, and many persons commented on their improved appearance.

About ten times as much new growth occurred on these trees as on the untreated trees. The fruit was larger, and a very large percentage of it entirely clean. The storm of September 28-29, however, blew down and broke many of the trees and knocked approximately 87.2 per cent of the fruit to the ground, preventing bringing the work to a completely satisfactory conclusion.

It was possible, however, to count most of the fruit on the ground and that on the trees and examine it for insect injuries. There were practically twice as many fruits per producing tree left on the treated as on the untreated trees. Owing to the morass of weeds in the untreated block and to much of the fruit having been removed and sold by the owner, it was impracticable to count the fallen fruit in that block. In the treated block all the fruit which was not washed out of the orchard was counted and examined for insect injury. There were on the ground and on the trees 69,672 sweet oranges, tangerines, and mandarins, which, averaging about 200 to the box, made approximately 348 packed boxes of fruit. It was estimated that nearly one-fourth of the fruit was not recovered. The production was, therefore, about 435 boxes, or more than as much fruit as the entire orchard had produced the previous year, as a result of only one season's treatment.

The cost of the full treatment for the season was about 33 cents per tree. It is scarcely necessary to say that complete destruction of the ants would not bring about these results, nor did the ants in any degree prevent their attainment.

EXPERIMENTS IN CONTROLLING THE ARGENTINE ANT.

POISONING TESTS.

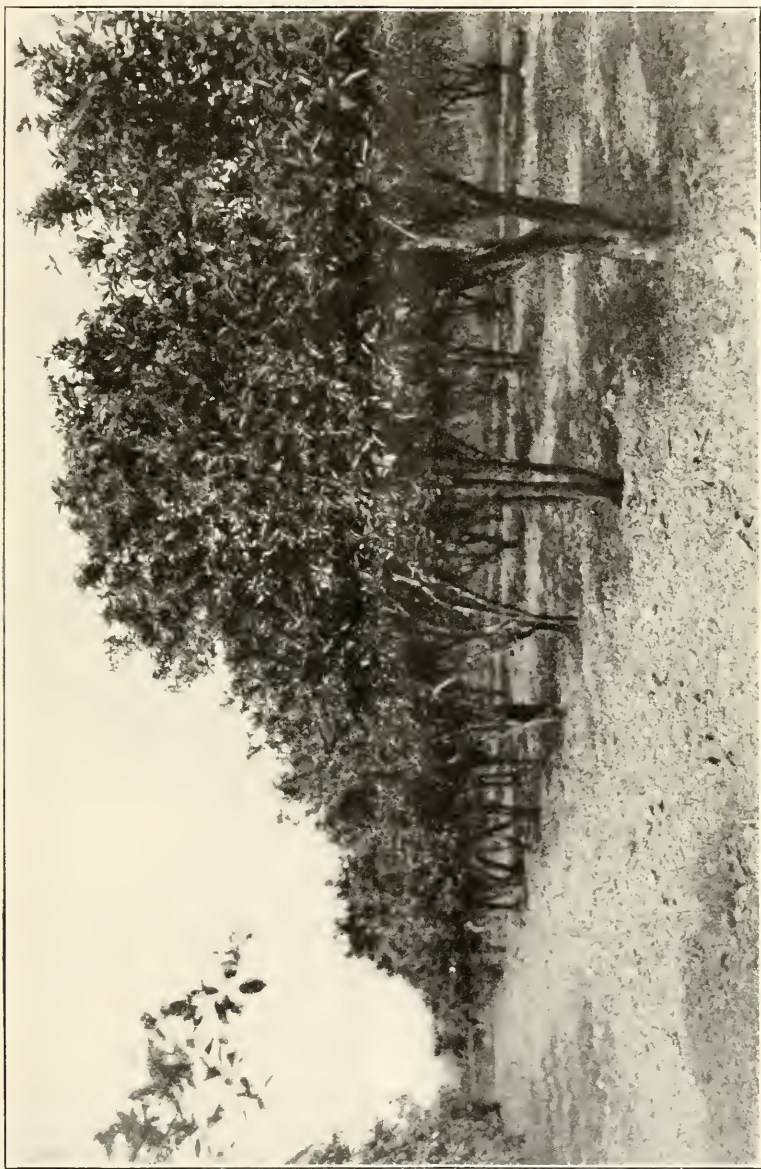
In the poisoning work conducted against the Argentine ant in Louisiana the following 16 poisons were tested: Strychnine sulphate, potassium cyanid, oxalic acid, arsenic trioxid, lead arsenate, Paris green, tartar emetic, oxid of antimony, mercuric chlorid, mercurous chlorid, copper sulphate, sulphate of iron, chrome alum, sodium arsenite, chloral hydrate, powdered extract of belladonna. As 14 of them were given a thorough trial at three different strengths in the field, and 20 further tests were made on imprisoned colonies, there were 62 experiments in all.

METHODS OF CONDUCTING POISONING TESTS.

The receptacle used for the poisoned sirup was a deep-shouldered fruit jar of the type illustrated in Plate IV, with a tin lid with rubber band attached. A single entrance hole for the ants was punched in the center of the lid. To aid the ants in reaching the sirup, a piece of sponge was put into each jar. Scrap or waste sponges entirely suitable for this use may be purchased at wholesale drug stores for about 25 cents per pound.

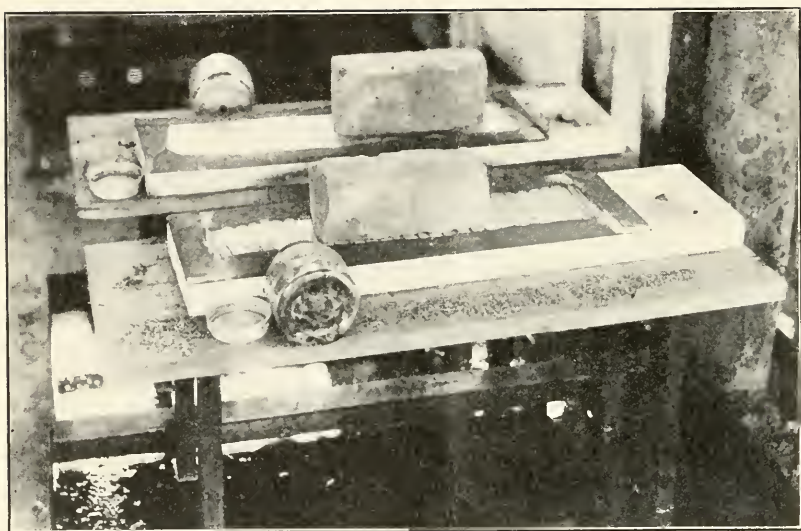
Upon beginning to forage at the poison, the ants would be traced to their nest and the location and size of the colony recorded, after which it would be watched and the effect of the poison noted. A definite amount of sirup, usually 4 or 8 ounces, was placed in each jar, every time, and the amounts taken by the ants thus learned.

In poisoning tests on imprisoned ants each colony was confined to a low table supporting a three-celled Janet type plaster of Paris formicary, furnished with vent holes covered with bronze gauze. The ants were allowed to roam at will on top of the formicary and the 4-inch margin between the sides of the formicary and the edge of the table. (See Pl. IV.) To prevent ants from leaving the tables, the latter were placed in shallow galvanized-iron pans about 8 inches wider and longer than the table tops, containing a lubricating oil costing from 15 to 25 cents per gallon. The advantages of this oil were the extreme slowness with which it evaporates, its lack of an odor which might disturb the ants, and its nondrying property. Fresh sirup, cockroaches or other meat, and water were always at



EXPERIMENTAL ORANGE GROVE AT OLLIE, LA., AFTER TREATMENT.

Note the poor shape and small top of the trees resulting from neglected pruning and too close planting. The black spots on the crown of the second and fourth trees are wounds caused by the "sore shin" disease. (Original.)



INTERIOR OF FORMICARIUM.

Type of formicary used in ant poisoning experiments, and method of preventing the escape of ants by resting tables in shallow pans of lubricating oil. (Original.)

hand on the table, in addition to the poison, in order to approximate field conditions as nearly as possible. With this apparatus and method of feeding, ant colonies have been kept in a state of health for nearly two years. In some cases, where the ants are confined for prolonged periods without flesh food, they feed upon their own eggs and young.

SUMMARY OF RESULTS OF POISONING TESTS.

In conducting tests on nonimprisoned ants, difficulty was experienced in determining the effect of the poison upon the ant colony. Desertion of the nest may mean that the ants have been destroyed, that the poison has merely impelled them to move, that they have moved from need of better quarters, or that they have discovered more abundant and suitable food elsewhere. The colony may move slowly from the immediate neighborhood of the poison, but its scouts continue to hang about the latter indefinitely. It may remain where it is and follow the original trail near the poison without visiting it. Slow migration may occur, giving the impression that the colony is being destroyed, when such is not the case. From 26 to 298 days were required to bring out the results. If the poison dosage is too strong, the ants will leave it before much harm befalls them; if so weak as to assure continuous feeding, its action is extremely slow. The amounts of poisoned sirup consumed by the ants in field tests varied from as low as 0.04 ounce per day over a period of 189 days to as high as 1.2 ounces per day for 296 days. Dead worker ants were found in or near the poison jars only in the case of three of the poisons, viz, strychnine, potassium cyanid, and arsenic. Large numbers of dead ants occurred often only at the jars containing potassium cyanid.

The poisons selected for a final testing upon imprisoned colonies were strychnine, potassium cyanid, arsenic trioxid, lead arsenate, mercuric and mercurous chlorid, tartar emetic, sodium arsenite, chloral hydrate, and belladonna. The first symptoms of poisoning shown by the imprisoned colonies are a strong desire on the part of the workers for water and assiduous cleansing of the body, particularly the jaws. An ant will commonly regurgitate a dose of poison, and a sister worker will cleanse her distended jaws with great thoroughness, repeatedly going over them with the mandibles and tongue. The next effect upon the colony is generally the death of some of the young, followed by a slackening, and finally a cessation of oviposition. The young then die rapidly, followed by workers, until all of both phases are dead. The queens then begin to do their own foraging, and finally succumb to the poison, at times not until several days after the demise of the last worker.

The poisons which came through both tests with the best record were:

- (1) Chloral hydrate, 3 gm., to sirup, 120 gm.
- (2) Sodium arsenite, 0.143 to 0.287 gm., to sirup, 120 gm.
- (3) Arsenic trioxid, 0.125 to 0.250 gm., to sirup, 120 gm.
- (4) Lead arsenate, 1.0 gm., to sirup, 120 gm.
- (5) Tartar emetic, 0.525 gm., to sirup 120 gm.

By far the most rapid and successful of all was the chloral hydrate mixture.

POISONING ANTS IN THE ORANGE GROVES.

Two experiments were conducted in an attempt to destroy the ants in orange groves by means of poisoning. One of these, in which the trees were not banded and weeds were allowed to flourish during the experiment, failed to have any appreciable effect upon the ants.

In the other one a plat of 237 orange trees was first completely isolated from the rest of the orchard by means of barrier ditches. All weeds and trash were then removed from the plat, and the trees all banded with an adhesive mixture, thus limiting the food supply for ants within the plat to the poison and a comparatively few rotting oranges, dead insects, and fiddler crabs. The ground in the plat was almost covered with a mass of ants, there being 250 "very large," "large," and "small" colonies, or more than one for every tree. The ants took the poison intermittently, attendance being abundant at certain jars at one time, at others the next, and attendance at the poison was no doubt greater than it would otherwise have been because of the scarcity of food.

The result of the poisoning and tree banding together was to reduce the ants after about four months to 2 "large" and 17 "very small" colonies. On ordinary inspection and comparison with the adjoining plat one would say that there were no ants left in the treated plat. The poison, in itself, was not a marked success, however, as cutting off the food supply had caused fully 75 per cent of the ants to migrate, as shown by the speed with which the first large disappearance of ants took place, and the frequent occurrence of thousands of dead ants on the water in the ditches.

USE OF TREE-BANDING MIXTURES.

It seems doubtful whether adhesive and other repellent mixtures to be applied to the trunks of the trees will ever be used extensively as ant barriers in Louisiana orange groves. Such barriers do not reduce the ant population and can not be considered as a positive means of control. When used on a large scale bands of this sort need more or less frequent inspection and renewal or respreading, and the cost of

maintenance would not be justified under present conditions by the increased crop returns.

In Los Angeles County, Cal., it appears that the citrus mealybug could be completely controlled in many cases merely by excluding the ants from the trees. Should that condition remain indefinitely, banding the trees would probably be as cheap a method of checking the mealybug as any other. At all events tree-banding mixtures will always have a use in protecting yard and ornamental trees, beehives, etc., from the ants. They may be used also to advantage in some cases in connection with poisoning and trapping the ants.

In an endeavor to discover an ant barrier of this nature which would be impervious to changes in the weather, and which would only require infrequent renewal or respraying, more than 20 mixtures were tested upon orange, fig, and other trees. Lack of space prevents including detailed results of the individual experiments, and only the general conclusions already published elsewhere¹ will be stated.

ADHESIVE MIXTURES.

The most effective material of the adhesive type tested was made after the following formula:

Flowers of sulphur, part by weight	1
Commercial tree adhesive, parts by weight	6

All the lumps in the sulphur should be broken and the two ingredients thoroughly stirred together with a wooden paddle. The sulphur not only greatly prolongs the softness of the material, but appears to have a sufficiently repellent effect upon the ants to prevent them from bridging the bands with bits of trash or their own bodies. This mixture will remain effective in rainy, foggy, or exceptionally dry weather for from 3 to 5 months. If directly exposed for long periods to the sun, however, the surface becomes hard enough for ants to pass, and the bands should, therefore, be applied where the shade of the tree will protect them. This mixture must not be applied directly to the bark of trees, as it will be to some extent absorbed and may in time cause injury. It should be applied to tire tape or other waterproof material which has first been wrapped about the trunk.

REPELLENT MERCURIC SHELLAC.

It is well known that corrosive sublimate has a strongly repellent effect upon the ants, and is the active ingredient in most, if not all, of the "ant tapes" found on the market, as well as of those watery solutions to be applied to household furniture with a paint brush.

¹ Horton, J. R. Some weather-proof bands for use against ants. *In* Mo. Bul. Cal. St. Comm. Hort., v. 5, p. 419-421. 1916.

It seemed desirable to give this chemical a thorough trial in the field, but it was necessary to devise a means of protecting the mercuric salt from rain. The ant tapes and liquids on the market were useless for outdoor work, because their value was quickly destroyed by moisture.

In original experiments performed by the writer it was found that the corrosive sublimate could be made impervious to water by dissolving this salt in an alcoholic solution of shellac. A considerable experimentation, in which both methyl and ethyl alcohol and various strengths of the mercury were used, resulted in the following formula, which was most satisfactory:

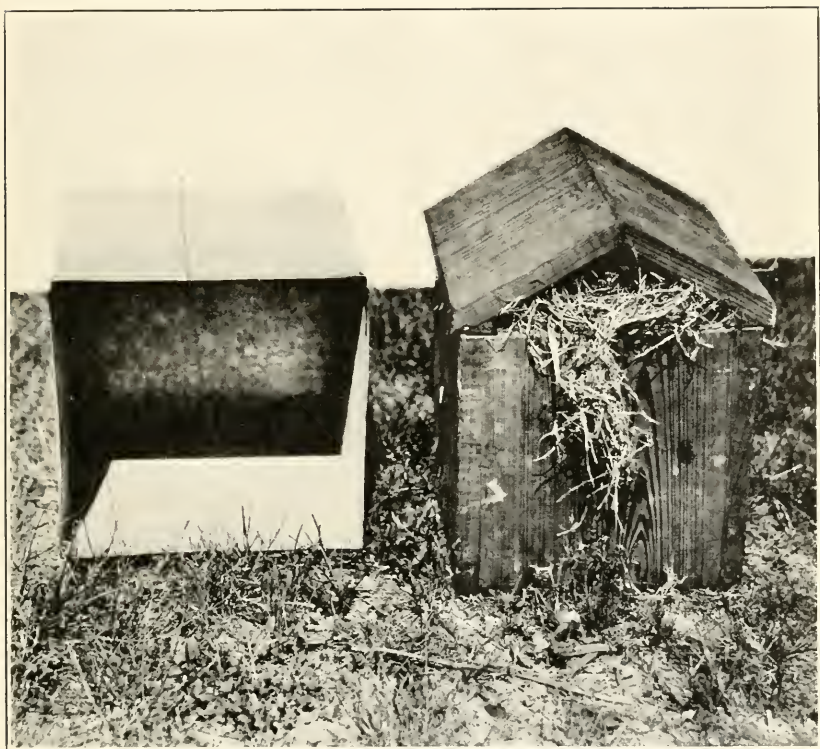
Corrosive sublimate-----	gm--	20
Ethyl alcohol-----	c. c--	60
Shellac-----	gm--	31

The corrosive sublimate is first dissolved in the alcohol, then the shellac added, and the mixture shaken until all is dissolved.

In the few tests made with this mixture in the field it proved effective against the ants for about two months under the most trying conditions. It is less effective, however, than the adhesive mixture previously described, and too expensive for use on a large scale. It must never be applied directly to trees, as it will quickly kill the bark clear through and ultimately destroy the tree. It may be used by first applying thickly to strips of cloth, or soaking the latter in the solution, and then allowing them to dry out thoroughly. This method is, however, too tedious and expensive for practical use.

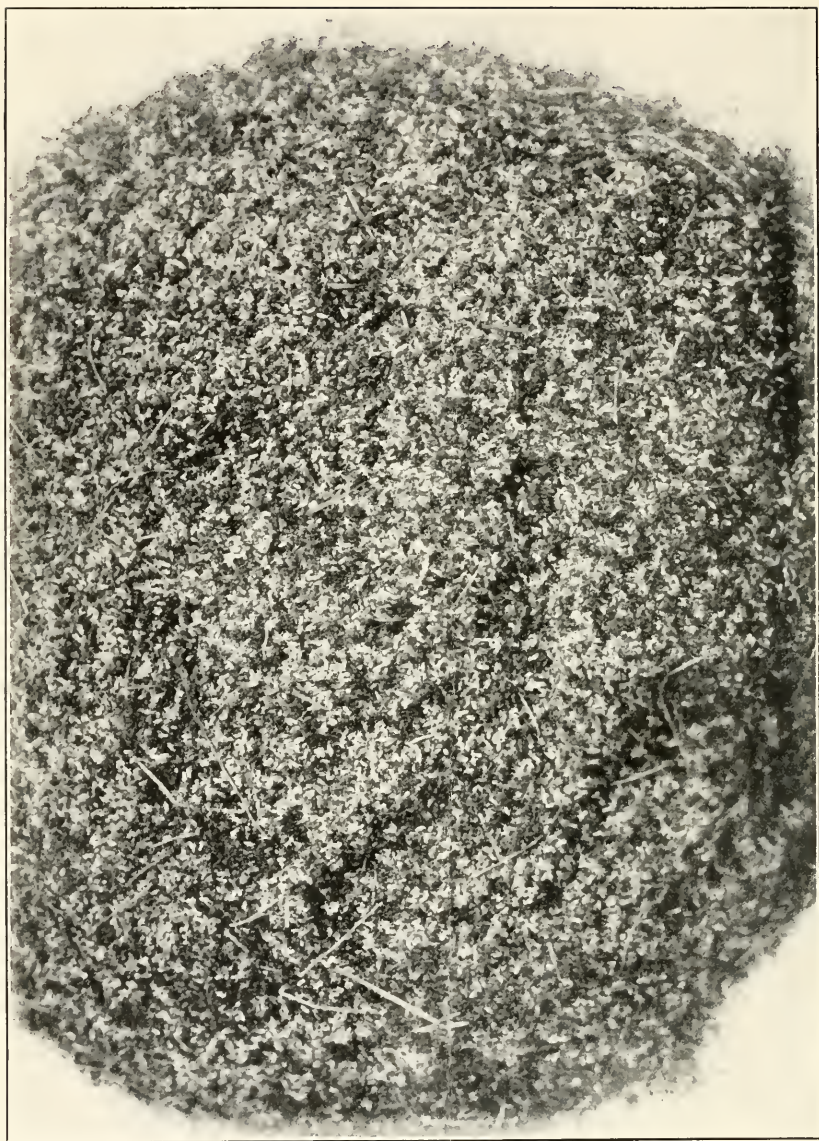
Shellac solution of corrosive sublimate, made after the foregoing formula and painted in bands from 6 to 8 inches wide on the legs of tables, refrigerators, etc., where food is kept, ordinarily will keep the ants away for a year or more. The banding material will not long retain its strength when applied to metal surfaces, such as stove legs and galvanized-iron garbage pails.

There is considerable danger attendant upon the careless use of corrosive sublimate, but if the precaution is taken not to get it into a cut or abrasion, or into the mouth or eyes while mixing, there is nothing to fear from it. It is much safer to handle in the form of a shellac solution than in that of an ant tape, being applied with a paint brush and not requiring any direct handling whatever. Once the "paint" has become dry there is no chance for the corrosive sublimate to shake loose and get into food. In making ant tape, on the contrary, there is danger of splashing the solution into the face or of getting it into a slight cut on the hands in soaking and drying the cloth strips, and when these are applied the loose poison in the fibers of the cloth is a constant source of danger to young children and domestic pets.



TRAPPING THE ARGENTINE ANT.

Ant trap nest and fumigating cover used in destroying the Argentine ant in the orange groves of Louisiana. (Original.)



TRAPPING THE ARGENTINE ANT.

Mass of dead ants killed in one of the traps nests at Happy Jack, La. About one-third natural size. (Original.)

EFFECT OF CORROSIVE SUBLIMATE.

A poisonous emanation appears to be given off by the mercuric shellac band which is very injurious to the ants, as one example of the behavior of ants which have crossed it will illustrate. An ant attempting to cross one of these bands suddenly stopped when part way across and began to stroke the antennæ with the first pair of legs. It remained on the band about $1\frac{1}{2}$ minutes, turning slowly about, stroking the antennæ, and drawing the legs between the mandibles. It then slowly retraced its steps off the band and moved aimlessly about for a time, often getting in the way of other ants. Soon one of these stopped and took hold of one of its antennæ. This made it active long enough to disengage itself, when it again became sluggish and wandered aimlessly. This continued as long as it was watched—about 10 minutes. Other ants, some of which were themselves sick, were trying to drag their dizzy fellows to a shelter. Most of the sick ants finally became very sluggish and many of them fell from the tree.

TRAPPING THE ARGENTINE ANT IN LOUISIANA.

By far the best and the only practical means of destroying the Argentine ant in the orange groves of Louisiana is by trapping. The discovery that the ants would collect in large numbers in boxes of decaying vegetation in winter was first made by Messrs. Newell and Barber, who described a method of destroying them based on this fact.¹ The method of trapping about to be described differs in several important respects, however, from that recommended by these gentlemen. It is based mainly upon the fact that a very slight rain at any season of the year will cause the ant colonies to come out of the ground, where most of them nest, and seek dry, sheltered places.

EFFECT OF RAINS UPON THE ANTS.

The favorite rainy-weather nesting places of the ants are under loose boards, piles of lumber, boxes, logs, sacks, and pieces of cloth, piles of bricks, piles of dead weeds, under and in the sides of buildings, etc. They also preferably seek high ground, and, other conditions being equal, the largest colonies will be found on the ditch banks and the high ground at the base of the trees. Just as foraging workers often complete a partial natural shelter found upon a tree or elsewhere by making walls of bits of trash, the ants often build elaborate structures of soil particles and trash under the loose boards and other shelters found on or near the ground.

The idea of using the traps about to be described was first suggested by the behavior of the ant colonies in an orange orchard in

¹ Op. cit., p. 95-96.

which a poisoning experiment was being conducted. As the jars used would be partly filled with water every time it rained, a shelter was made for each of them out of two ends of an orange box nailed together in the shape of a gable. Soon after these covers had been laid, every one was found to harbor an ant colony which crowded it to its fullest capacity. Protection from the rain alone not satisfying the ants, they shut out the light and drafts by completely filling in the space between the jar and the top and ends of the cover with particles of soil. Each nest was no doubt ideal from the ants' point of view. Each was honeycombed with galleries of all shapes and sizes, ramifying in every direction. Any desired degree of moisture could probably be had in these galleries, those nearest the top being driest, and those directly on the surface of the ground most humid. The occupants would only need to move to underground quarters should prolonged dry weather occur. Each of these "ant castles," as they might be called, was perfectly protected from rain by a good pine roof. On removing the roof and looking into the galleries, thousands of eggs, young, and queens were revealed. Many solid masses of young and eggs as large as a hen's egg could be collected in these shelters. It was very evident that the ants could be much more rapidly destroyed when gathered together in this manner than by the tedious and unsatisfactory method of feeding them poison.

Protection from rain and drafts, good drainage, and darkness being the principal nesting requisites of the ants, it appeared that these requirements could best be met by a box with a roof. It was also found that ants could be induced to mass more thoroughly in numerous comparatively small colonies than in a few extremely large ones. A small covered box-trap was, therefore, given a trial, 15 of them being used in the first test. This was so satisfactory that it was followed by a large-scale experiment in which over 400 traps were used.

DESCRIPTION OF ANT TRAPS AND FUMIGATING COVERS.

The first traps (see Pl. V) were made of $\frac{3}{4}$ -inch cypress; but sap pine proved to be just as good and was cheaper. Each trap consisted of the following 9 pieces: Two sides, 12 by 12 inches; 2 sides, 10 by 12 inches; 1 bottom, 10 by 10 inches; 2 top pieces, 8 by 12 inches, and 2 pieces of triangular molding 12 inches long. First the smaller sides and bottom are fastened together with rosined nails or screws to prevent warping, then the larger sides added. The top pieces are fastened together in the form of a gable, with a tight joint, this roof being set loosely on top of the box. The pieces of molding are nailed across the inner side of the roof where it touches the top of the trap to hold it in place.

Covers to keep the gas in while fumigating are made of 28-gauge galvanized iron, each consisting of one piece 38 inches by 13 $\frac{1}{4}$ inches,

bent into two right angles, forming two sides and the top, and two pieces $13\frac{1}{4}$ by $13\frac{1}{4}$ inches, forming the other two sides. The edges of the latter two pieces are folded inwardly over those of the first piece and hammered tightly together. Covers with soldered, instead of hammered, seams are preferable, however, unless the latter are very well made. The completed cover should measure $12\frac{1}{2}$ by $12\frac{1}{2}$ by $12\frac{1}{2}$ inches inside, leaving a margin of $\frac{1}{4}$ inch to turn down all around the outside to reinforce the open edge.

RESULTS OF ANT-TRAPPING EXPERIMENT.

The experiment, the results of which are about to be briefly stated, was conducted in a block of approximately 19 acres¹ of bearing orange trees completely overrun with ants, located at Happy Jack, La. The traps, numbering 415 in all, or about 22 per acre, were set April 21-22, 1914. A trap was placed on a slight elevation at the outer edge of the spread of every second tree each way, or one trap to each four trees. Tests of various kinds of filler had shown previously that the best for summer was dry grass and weeds; for winter, equal parts of decaying manure and dry grass and weeds. From the time of setting the traps until the first rain, about 56 days, the ants were nesting almost wholly at from 8 inches to $1\frac{1}{2}$ feet in the ground. Even after such a period of prolonged drought, however, a rain of about 0.2 inch, occurring June 18, 1914, was sufficient to drive them into the traps in large numbers.

Tests of different strengths of carbon disulphid and strong ammonia water as fumigants proved that 12 ounces per trap of the ammonia was satisfactory. The carbon disulphid, however, proved satisfactory at as little as 2 fluid ounces per trap, allowing the traps to fumigate for 1 hour.

The first fumigation was started June 23, at which time it was necessary to fumigate 334 of the traps, only those which contained large and complete colonies being disturbed. The second, third, and fourth fumigations were started July 21, August 26, and September 28, respectively, completing the summer's killing. A solid mass of ants, in all stages, nearly as large as a man's hat, was killed in each trap each time. The workers and even the queens were so numerous that it was entirely out of the question to separate and count them in any large number of the traps (see Pl. VI). The queens, however, were counted each time in one or two traps with an average killing, and in this way it was estimated that 1,161,323 queens were killed in these first four or summer fumigations, 600,000 in the first two, 295,895 in the third, and 265,428 in the fourth. All of the traps were

¹ All references to the acre are to the "square acre," not the "acre front."

full and fumigated the second and third times, and 404 of them the fourth time. The next five fumigations were started November 12, and December 4, 1914, and January 7, February 25, and June 7, 1915, the number of traps fumigated being 409, 403, 405, 305, and 21 at each respective fumigation. The number of queens killed in the last five fumigations was 34,765, 32,240, 55,080, 19,215, and 4,599, respectively.

Before undertaking the work, an agreement had been made between the officers of the Bureau of Entomology and the orange grove company by which that company was, among other things, to maintain open barrier ditches¹ around the treated block, and keep that block of the orchard in a state of clean cultivation at its own expense throughout the course of the experiment. Succeeding events, however, prevented the company, through no fault of its officers, from carrying out its part of the agreement. The result was that the ditches were not maintained, and weeds and trash remained in the orchard at all times; hence, many ants migrated into the block, often being traced directly to the traps, and other nesting places besides the traps were numerous. The persistent habit of the queen ants of forming small offshoot colonies along the worker's trails is at once the principal means of spread and a great safeguard to the species. In the interval from the second to fifth fumigations, from 41 to 46 trails of ants were found migrating into the orchards from the direction of the levee alone, at every examination. Many ants from outside the orchard were, therefore, killed in the traps, and the duration of the work was unnecessarily prolonged thereby. The record of ants killed at the various fumigations is given in Table VIII.

TABLE VIII.—*Results of ant-trapping experiment in an orange grove. Louisiana, 1914-15.*

Fumigation No.	Date of beginning.	Number of traps necessary to fumigate.	Estimated number of queen ants killed.	Fumigation No.	Date of beginning.	Number of traps necessary to fumigate.	Estimated number of queen ants killed
1.....	June 23, 1914	334	600,000	7.....	Jan. 7, 1915	405	55,080
2.....	July 21, 1914	415		8.....	Feb. 25, 1915	305	19,215
3.....	Aug. 26, 1914	415		9.....	June 7, 1915	21	4,599
4.....	Sept. 28, 1914	404	265,428	Total.....			1,307,222
5.....	Nov. 12, 1914	409	34,765				
6.....	Dec. 4, 1914	403	32,240				

¹ It should be noted that a ditch of this sort already occurred along each side of the orchard from front to back, being constantly necessary to drain off the surface water. It was only necessary to clean the weeds out of these ditches and deepen them a little, and excavate a short ditch across the front of the place. The ants were prevented from coming in at the rear by the marsh.

After the eighth fumigation, February 27, 1915, there was very decided reduction in the number of ants in the orchard, and the foreman of the place remarked that the ants were getting very scarce in the block. Only straggling workers occurred in a few of the traps from this time until the next fumigation, June 7. On March 25 examination of 30 orange trees revealed only one scout ant, and it was reported that there were no more ants about. A ranch hand said he had uncovered only three nests in plowing the entire block, while in a neighboring orchard (which had been treated for ants by the flooding method for three years or longer) he had raised so many he could not keep track of them. On the same date the ants were extremely numerous in the orange trees in an adjoining grove.

A further examination on April 16 showed ants to be present on only 1 in 40 trees, and then not numerous enough to form trails. *There were no ants at the blossoms or at the numerous aphids on the trees.* Some large umbrella trees, which usually had from six to eight large trails, were absolutely free from ants. In the house it was no longer necessary to isolate food supplies, beds, etc., from the ants, from which there was not the slightest further annoyance, as stated by both the foreman and his wife. In the upper portion of the same property, about 90 rows from the experimental block, on the contrary, the ants were running in heavy trails up all the trees and were numerous in the blossoms and at aphids.

After the February fumigation another was not warranted for about three and one-half months, or until June 7, when 21 of the traps contained sufficiently large colonies to seem to warrant their destruction. The killing of queens had been reduced from nearly 300,000 in each of the first three or four fumigations to less than 5,000, and, of course, all the other stages had been comparably reduced. The experiment was a complete success, for it reduced the ants to negligible numbers.

The following rough but not widely erroneous estimates will give an idea of the populousness of the ants in this orchard: The total estimated number of queens killed, as reference to Table VII will show, was 1,307,222. The workers and young must be estimated by volume. In the first four fumigations every trap fumigated contained fully one-half gallon of ants in all stages, and in each of the succeeding five nearly a quart. The total number of traps fumigated in the first four operations was 1,568; therefore 784 gallons, or about $15\frac{1}{2}$ barrels, of ants were destroyed. In the remaining five fumigations there were 1,543 traps; therefore about 385 gallons, or about $7\frac{1}{2}$ barrels, of ants were destroyed. The bulk of the ants destroyed in this work, therefore, would be almost great enough to fill twenty-three 50-gallon barrels.

METHOD AND COST OF FUMIGATING ANT TRAPS.

It is recommended that not less than 25 traps per acre of 100 trees be used in ant trapping in the orange groves. There should also be 12 covers for each 100 traps. A trap should be placed near every other tree each way. For example, one near each of the first, third, and fifth trees in the first row, then similarly in the third, fifth, and seventh rows, etc. The traps should be located just under the outer spread of the trees, where they will not be in the way of the cultivator or so close to the tree that the latter will be injured by the fumigant. The distance from the trunk should be about 4 feet. They should be placed upon slight, level elevations made by throwing up and smoothing off a few shovelfuls of dirt.

The ants will be destroyed much faster if every part of the orchard, including ditch banks and the tree hills, is kept free from weeds, loose boards, boxes, sacks, etc. It is, of course, not recommended to plow and cultivate during the winter months, but the orchard should be kept clean during the summer. In winter the traps should be filled with damp but not wet stable manure and dry weeds, the manure occupying the lower half of the box. In summer the manure, which is used principally for its heat, may be omitted. It is important to keep the lids on the traps at all times, as they keep out the rain, a very essential condition, darken the nest, and in winter help to retain its warmth.

When the trap is full of ants and ready to fumigate the lid is thrown off, 2 fluid ounces of carbon disulphid poured in, and the cover quickly slipped on, the edges being banked with dirt to aid in retaining the gas. One man can do the work where the number of traps is small. Where the number of traps is larger they can be fumigated most efficiently by a crew of three men, one of whom measures and pours the liquid while the others remove the covers from fumigated traps, place them over those to be fumigated, and bank them with earth. A shovelful of soil tamped down at each side is sufficient. The traps must be allowed to fumigate for an hour. A crew of three men working continuously can handle 48 covers, removing them from one lot of traps and resetting them over the next in from 50 minutes to an hour. Two ounces of carbon disulphid will kill every ant in the trap and ants, worms, and sowbugs for 3 inches in the ground beneath. While the same trap filler may be used indefinitely, it and the traps should be given a thorough airing after each fumigation.

The figures here given on the cost of installing and operating the traps are based entirely upon the foregoing experiment conducted by the Bureau of Entomology. The cost of the traps, made of C-grade sap pine, all parts cut to fit, knocked down, was \$0.23 each,

to which must be added an additional \$0.08 for transportation and setting up, making a net cost of \$0.31 each. The covers were made and delivered for \$0.75 each. On this basis the first cost of traps and covers per acre would be about as follows:

25 traps, at \$0.31 each.....	\$7. 75
3 covers, at \$0.75 each.....	2. 25

Net cost of traps and covers per acre..... 10. 00

A crew of three have in practice fumigated 400 traps in 1½ eight-hour days, their services, at the rate of \$1.25 per day each, costing \$5.62. The carbon disulphid at that time cost \$10.75 per hundred pounds. On this basis the cost of fumigating per acre of 100 trees per time would be about as follows:

Cost of labor fumigating 25 traps, at \$0.014.....	\$0. 35
Cost of fumigant, 25 traps, at \$0.013.....	. 325

Net cost of fumigation per acre..... . 675

SUMMARY AND CONCLUSIONS.

Most of the orange groves of southern Louisiana, with the exception of well-tended groves and seedling orchards, have been declining in the last seven or eight years. As a rule, maximum productiveness is reached at from 7 to 10 years of age, after which it diminishes, the actual crop loss up to 1914 being approximately 37 per cent of the known possible production. The principal cause of this decline of trees and loss of crop, which has been largely blamed upon the Argentine ant, is cultural neglect.

The part played by the ant in causing this condition has been exaggerated. The only direct injury done by the ant is to destroy a negligible number of orange blossoms. The ants do not attend the armored scales of citrus or secure honeydew from them, nor do they disseminate the living scales. They do, however, disturb the predatory enemies of these scales, preventing the destruction of as large a proportion of them as would otherwise occur. Nevertheless, the natural enemies of the armored scales do not prevent heavy infestation even in orchards free from ants. The ant can not prevent the control of the armored scales in Louisiana by spraying nor will it increase the cost of spraying. Destruction of the ants will not control these scales, and they must be controlled if orange growing in that State is to be made profitable.

Under present conditions the Argentine ant does not cause exceptionally severe infestations in the orange groves of Louisiana, even of those soft scales to which it is most favorable. The mealybugs have not been of importance as an orange pest in ant-invaded orchards during the years 1913 to 1915, partly due to the effective-

ness of natural enemies, especially certain internal parasites, partly to overcrowding of the trees by armored scales and white flies, and partly because of the poor physical condition of the trees.

In Los Angeles County, Cal., where the trees are kept free from other scales and vigorously growing, the mealybugs increase tremendously as a result of ant attendance. Ordinarily they are kept under complete control, where the ants do not occur, by their predatory enemies. In orchards where fumigation has been neglected and the trees become overcrowded with the black scale, the mealybug does not benefit so much from ant attendance, and infestation is much milder.

The fluted scale has never been found in the orange groves proper of Louisiana, and the part played by the Argentine ant in causing the outbreak of this scale at New Orleans in 1916 is not known. The occurrence of this outbreak, closely following the 1915 hurricane, suggests the probability that the insect was largely spread by this means. The fluted scale is unable, under present conditions, to thrive on the orange trees of southern California even under the heaviest ant attendance, apparently being held in check principally by the Australian lady-beetle (*Novius cardinalis* Muls.), the green lacewings, and the dipterous larva *Cryptochaetum monophlebi* Skuse.

While the black scale occurs in New Orleans under constant attendance by the Argentine ant, the ant has failed to bring it into prominence there, and not a single infestation or even a single specimen has been discovered in any of the orange groves of Louisiana. In California the black scale infestations often become very severe after a single season during which fumigation has been neglected. In two years' time the insect is capable of increasing from almost none at all to such extreme numbers as to occupy every suitable feeding spot on the trees which it infests. Attendance by the ant for a single season does not noticeably increase the infestation of the black scale in California, where it reaches a maximum whether the ant is present or not. The natural enemies of this scale are not numerous and effective enough to control it.

While exceptionally large numbers of the soft brown scale occur on certain host plants or parts of such plants under ant attendance in Louisiana, the natural enemies of this scale, especially the internal parasites, continue to hold it to insignificant numbers in the orange groves under present conditions. In Riverside County, Cal., this scale appears to have increased considerably in certain ant-infested orchards, but is generally controlled along with other scales by fumigation. In Los Angeles County both the soft brown and the citricola scales are scarce in ant-invaded as well as other orchards. The soft brown scale, however, is undoubtedly more numerous on cam-

phor and bottle trees (*Sterculia diversifolia*) and some other plants in sections of Pasadena where the ants occur than in sections where they do not.

There is reason to believe that the Argentine ant may be an active agent in the spread of diseases through its habit of visiting various parts of the tree, and particularly freshly made wounds, for the purpose of feeding. It appears to introduce gummosis and wood-rotting fungi in this way more rapidly than could otherwise be the case. It may act as a conveyor of diseases of bacterial origin, such as the citrus canker, by carrying the causal organisms about on its legs and body.

The control of the Argentine ant in Louisiana by the trapping method described in preceding pages is entirely practicable at a moderate cost. If ants are deterred by barrier ditches from entering the grove rapidly, five or six fumigations about a month apart should so reduce the worst infestations that annoyance from ants will cease. Thereafter fumigation of a few of the traps once in every three to six months will suffice to prevent further molestation. The estimated cost of reducing the ants from most extreme numbers to the few remaining where there is effective control would be about \$6.03 per acre¹ for labor and fumigant, or not to exceed \$16.03, including the first cost of traps and covers. It is believed that large sections of territory where the annual rainfall is heavy could be effectively and economically freed from ants by this method if all the members of the community would cooperate in the undertaking. Although the labor of ant destruction might be somewhat prolonged in cities because of the numerous buildings and other suitable nesting places, this method, it is believed, might be advantageously adapted to city use.

Destruction of the ants in Louisiana orange groves will not effectively control the armored scales, or the white flies and the rust mite, and would not pay for itself in actual crop increase. Regardless of the ants many run-down orange groves in Louisiana can be so improved by one season's thorough spraying and cultural treatment as almost to double their production. The success of certain orchards in southern Louisiana demonstrates that oranges can be profitably grown there if the trees are carefully selected and planted and the best-known cultural practices and methods of insect control followed. The growing of citrus is a business which is increasingly requiring thoroughgoing business methods, and this applies in Louisiana as elsewhere.

¹ The term acre as used in southern Louisiana means an acre along the river front by 40 acres deep, and should not be confused with the present use of the term, signifying 160 square rods.

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UNITED STATES DEPARTMENT OF AGRICULTURE
BULLETIN No. 648

OFFICE OF THE SECRETARY

Contribution from the Office of Farm Management
W. J. SPILLMAN, Chief

Washington, D. C.



May 1, 1918

A FARM-MANAGEMENT SURVEY IN
BROOKS COUNTY, GEORGIA

By

E. S. HASKELL, Assistant Agriculturist

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Type of Farming	7	Organization	30
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DESCRIPTION OF AREA SURVEYED.

Brooks County is located in the southern part of the coastal plain, just west of the center of the southern tier of counties in Georgia, about 50 miles from the Gulf of Mexico. The area covered by this survey is in the southern half of the county, bordering on the Florida State line. The location is shown by the shaded portion of the map, figure 1.¹

This area was selected for study because here has been developed a diversified and profitable type of agriculture, with cotton retained as the chief single source of income. For years these farmers have developed the swine industry and the production on the farm of the products consumed in the home to a point that has been equaled in but few places in the South. It is believed that the type of farming found here embodies features that might with profit be adopted in many parts of the cotton belt. This is particularly true now that the recent rapid advance of the cotton-boll weevil into this section has forced many farmers to face the necessity of reorganizing their farms upon a basis involving less dependence than hitherto upon the

¹ For assistance in collecting the data upon which this study is based, acknowledgment is due to Messrs. M. A. Crosby, C. E. Hope, A. G. Smith, and F. D. Stevens, of the staff of the Office of Farm Management; to J. M. Pardom, Jr., temporarily employed by the Office of Farm Management; and to Messrs. S. H. Starr and E. C. Westbrook, of the faculty of the Georgia State College of Agriculture. Special acknowledgment is due Prof. Starr, who also assisted in tabulating the data.

single crop, cotton. At the time this survey was made (1914) the boll weevil had not invaded Georgia, but since then the entire southern part of the State has become infested. Of this, more will be said in another place.

The topography of the southern half of Brooks County is gently rolling to flat. Most of it has sufficient slope to provide good natural

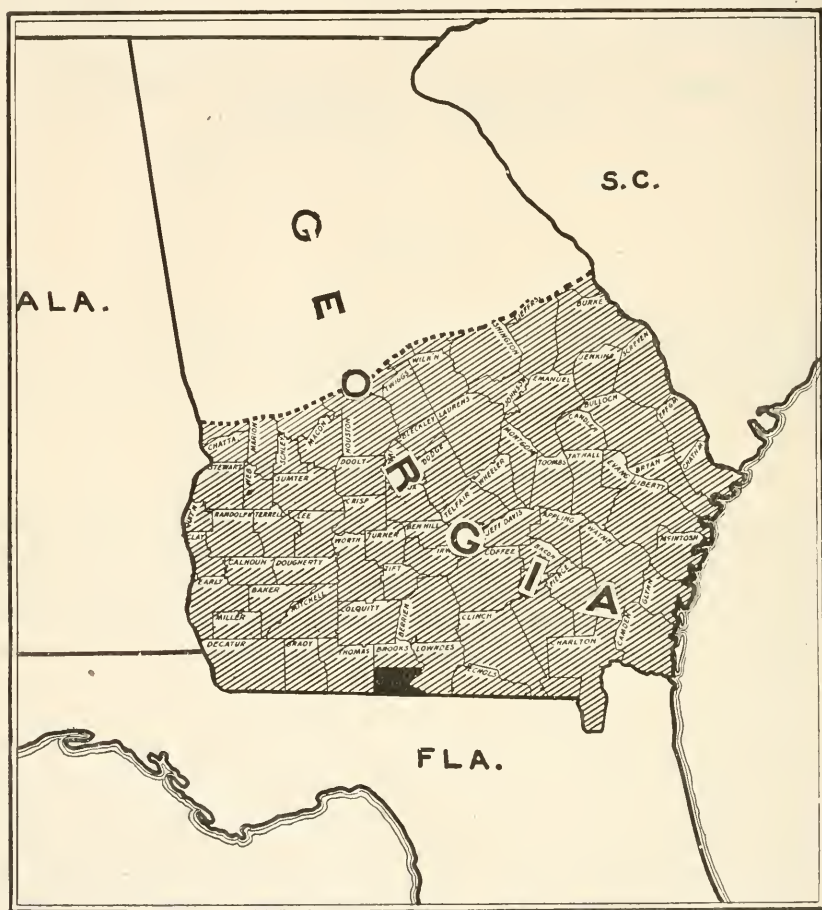


FIG. 1.—Map of Georgia, showing, in black, location of area surveyed. Shaded area indicates Coastal Plain section.

drainage, though considerable areas, particularly near the streams, are rendered swampy and of little value because of insufficient drainage.

The soil of this area is distinctly sandy, being mainly of the Norfolk sandy loam and closely related types. It is a gray sand, underlaid at a depth of from 10 to 40 inches or more by a yellow subsoil of a heavier texture. The soil is quite uniform over the area covered by this survey and is fairly representative of the soils over a consider-

able part of the coastal plain of this and the adjoining States. Farther north in the county the soils become gradually heavier, grading into the Ruston and Tifton series, but this survey has been confined to farms on the lighter soils found in the southern half of the county.

The climate of Brooks County is warm and equable. The winters are mild, and the summers, though long and warm, are tempered by Gulf breezes. Snow falls rarely, and temperatures lower than 30° F. seldom occur, though thin ice frequently forms during the winter months. Killing frosts may occur any time between November 15 and March 1. The annual precipitation amounts to 52 inches; the heaviest rainfall occurs during the months of June, July, and August. In figure 2 the average precipitation and that for the year 1914 are shown by months.

Quitman, the county seat, with a population of about 4,000, is just south of the center of the county and in the northern part of the area included in this survey. The Atlantic Coast Line Railroad crosses the county from east to west and the South Georgia Railroad from north to south,

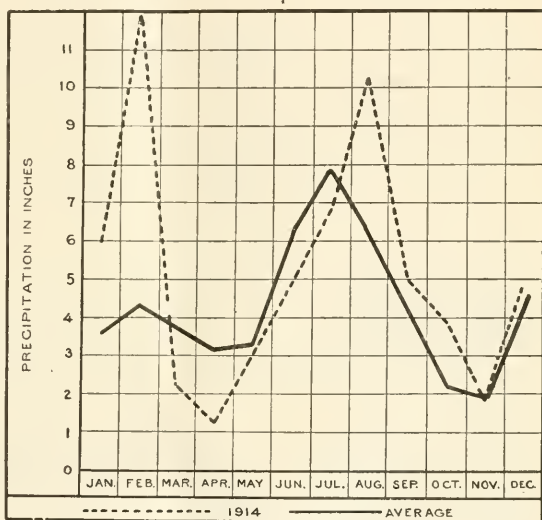


FIG. 2.—Precipitation by months at Quitman, Ga.

both passing through Quitman. These two railroads provide most of the area with good transportation facilities to outside markets, though some parts of the area, notably in the southwestern part of the county, are 8 to 10 miles or more from shipping points. The public roads of the county are of sandy clay, and the principal roads are being rapidly improved.

For years Brooks County has grown nearly all the live-stock feedstuffs consumed, together with a surplus to be sold in other markets. As a result, the local prices for such feeds are appreciably lower than those that prevail in the near-by counties which continue to purchase a part of their feeds from outside sources. Thus, in this county, the 1914 prices of corn and oats averaged about 75 cents and 50 cents per bushel, respectively, as compared with \$1 and 75 cents throughout the greater part of the State.

Brooks County has long been noted for the amount and quality of pork produced, much of which has brought a substantial premium in the larger markets of this and adjoining States. Until recently, practically all the pork was killed and cured on the farms; but a packing plant is now in operation in an adjoining county, thus providing a ready market for live stock on the hoof.

Brooks County was organized in 1858. The pioneer settlers came to this section largely from the older parts of the State early in the last century, but it was not until the first railroad, the present Atlantic Coast Line, was built, just prior to 1860, that settlement was given an impetus. The older settlers came largely from northern Georgia, the Carolinas, and Virginia.

The direction and rate of the development of the agriculture of the county are shown by the census data presented in Table 1. In 1860, 15.3 per cent of the land area was classed as improved farm land, a percentage that increased through each succeeding decade to 36.9 per cent at the time of the last census. A large part of the county is still covered by longleaf pine and other timber.

TABLE 1.—*Census data, Brooks County, Ga.*

Year.....	1860	1870	1880	1890	1900	1910
Number of farms <i>a</i>	300	394	930	1,176	1,823	2,646
Per cent of land in farms.....	81.1	65.8	83.9	74.6	87.6	85.8
Per cent of farm land improved.....	18.8	28.0	27.4	33.7	37.4	43.0
Per cent of land area in improved farm land.....	15.3	18.4	23.2	25.2	32.7	36.9
Acres per farm.....	890	550	297	209	158	106.6
Improved acres per farm.....	168	152	82	70	59	45.9
Value of farm land per acre.....	\$1.05	\$1.12	\$3.79	\$1.76	\$4.65	\$14.60
Value of farm property per farm.....	4,954.00	3,097.00	1,465.00	1,296.00	1,219.00	2,377.00
Per cent of farms operated by owners and managers.....			66.2	62.9	50.3	41.5
Per cent of farms operated by cash tenants.....			14.4	15.7	35.9	26.6
Per cent of farms operated by share tenants <i>a</i>			19.4	21.4	13.8	31.9
Number of horses on farms.....	657	491	823	956	1,192	1,205
Number of mules on farms.....	856	777	958	1,225	1,776	2,875
Number of cattle on farms.....	14,797	8,196	13,032	11,319	11,170	14,178
Number of sheep on farms.....	3,113	4,921	4,596	1,946	961	610
Number of swine on farms.....	18,629	11,087	17,243	22,766	29,885	47,210
Number of swine per farm.....	62.1	28.3	18.5	19.4	16.4	17.8
Number of swine per 100 acres improved land.....	37.0	18.3	22.6	27.5	27.8	38.9
Cotton.....	acres.....		21,255	22,161	16,096	34,065
	bales.....	4,406	3,466	6,288	9,194	13,977
Corn.....	acres.....		23,027	26,157	38,428	40,121
	bushels.....	223,353	171,190	173,530	270,978	384,220
Oats.....	acres.....		14,087	13,225	11,299	9,512
	bushels.....	6,911	45,716	163,862	122,775	104,530
Rye.....	acres.....		161	111	116	279
	bushels.....	1,914	1,738	879	565	500
Peanuts.....	acres.....			6,884	10,307	14,775
	bushels.....			91,685	196,724	365,395

a It should be borne in mind that in the census returns croppers are treated as farm operators, though in reality they are wage hands receiving their wage in the form of a share of the crop. The numbers of actual farms are, therefore, considerably smaller than given in the table, and the average sizes of farms are correspondingly larger. Most of the farmers classed as "share tenants" are in reality croppers. There are but few share tenants, properly speaking, in Brooks County.

From the first, cotton and corn have been the crops of greatest importance. By 1900 the cotton acreage had declined, relatively, as compared with other crops, following a number of years of low cotton prices, but since that date cotton has been developed more rapidly than any of the other crops. The acreage of oats increased rapidly up to 1880, but since then it has steadily declined both in actual acreage and relatively. The plantings of rye have been increasing since 1880, but the total acreage is still small, this crop being used mainly for pasture purposes. The rapid increase in the planting of peanuts is noteworthy, the acreage having increased from 6,884 acres in 1880 to 14,775 in 1910. This increase has been coincident with and a result of the development of the swine industry. The peanut acreage in Brooks County was in 1910 considerably in excess of that of any other county in Georgia, and equal to nearly 10 per cent of the total for the State.

Of the different classes of live stock other than work stock, swine is the only one that has increased in importance. The number of sheep has declined rapidly since 1870, to an insignificant number, and the number of cattle was nearly the same at the time of the last census as it was in 1860. The number of hogs in the county declined somewhat from 1860 to 1870, but since then the number has constantly increased from 11,087 to 47,210 in 1910. Measured in terms of the number per 100 acres of improved farm land, the number of hogs declined from 37 to 18.3 during the decade between 1860 and 1870, but since that time the number has increased to 38.9 per 100 acres.

Since this survey was made the acreage of peanuts grown and the number of hogs produced have increased very rapidly. This has been due partly to the better market offered for hogs, but principally to the invasion of the boll weevil, which has greatly increased the hazard of cotton growing.

METHOD AND SCOPE OF INVESTIGATION.

In this study a record was obtained from each farmer of the amount and value of each class of farm property; the amounts, sources, and nature of all receipts and expenses; the amounts and values of each item contributed by the farm toward the family living; the amount of labor expended on each enterprise, and data on numerous other factors necessary in making a complete analysis of the farm business and calculating the cost of each productive enterprise. The methods and details of calculating costs will be discussed in another place.

A farm-management survey should represent conditions that are as nearly normal as possible if the results are to be useful and of wide application. This is particularly true of crop yields and mar-

ket conditions. Yields in Brooks County for the year covered by this study (1914) were approximately normal for all crops except cotton, which made yields somewhat above the average. This high yield would tend to a certain extent to present results bearing on the cotton crop in a too favorable light.

However, the market price of cotton during the year studied was low, owing to conditions growing out of the European war. The average 5-year price received by these 106 farmers was estimated by them to be 10.4 cents per pound of gross lint, whereas for the 1914 crop they received 7.1 cents, or about 32 per cent below normal. Undoubtedly this estimated 5-year price of cotton was conservative, a fact which would tend to counterbalance the effect of the rather

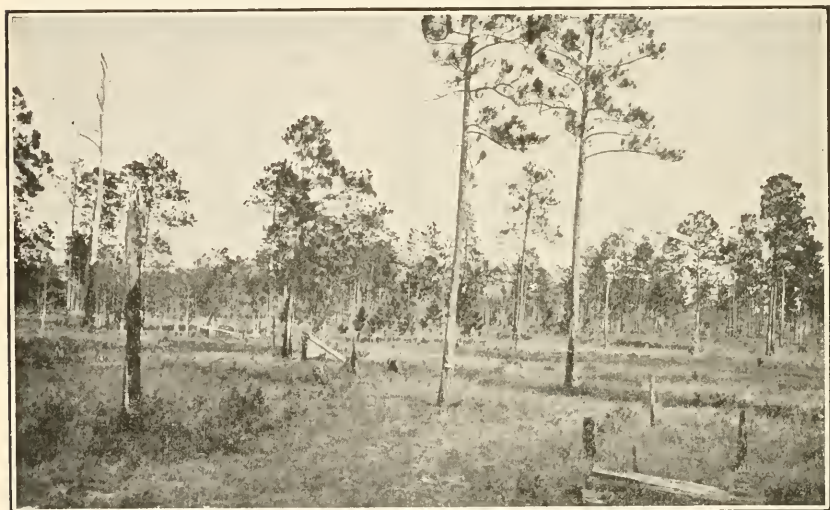


FIG. 3.—Woodland constitutes approximately half of the farm area. The prevailing timber is the long leaf pine, which is rapidly being turpented.

large yield. To correct the effect of this abnormality, the average price received by each farmer for cotton during the preceding 5-year period was substituted for the 1914 price in figuring the returns from the farm.

The price of watermelons fell during the shipping season to a low figure, with the result that many of the farmers, particularly those who had a late crop, received a very low price for a part of the crop, and many melons which otherwise would have been marketable were not even harvested. The average price received for the melons sold from farms studied was \$52.11 per carload, whereas the estimated average 5-year price amounted to \$57.80. In every case where the price received was abnormal, the farmer's estimated 5-year average price was substituted.

Market conditions were normal for all crops sold except cotton and melons, and it is believed that with these substitutions men-

tioned the results of this survey represent a close approximation to average conditions. It is true, however, that the cattle market was somewhat low, but this affected appreciably the income from only three of the farms. Also the price of hogs was slightly depressed, but not sufficiently so to warrant substitutions.

Numerous losses from hog cholera occurred throughout the county, and on a few of the farms studied such losses were serious, but taken together these losses represented approximately the average losses from that source during the preceding years.

TYPE OF FARMING.

Table II shows how the farm area is divided. The 106 farms surveyed average in size 331 acres, of which less than half, or 145 acres, are devoted to planted crops. Scarcely any idle crop land

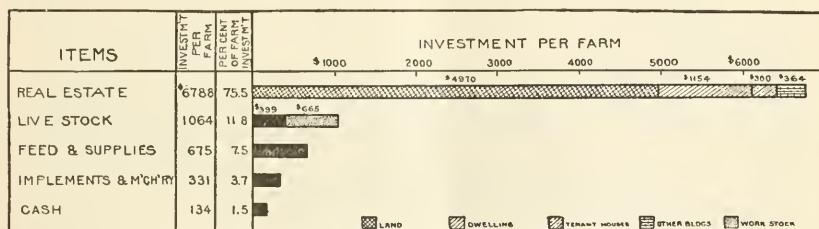


FIG. 4.—Distribution of farm investment.

is found, and less than 2 acres per farm of pasture in rotation. Permanent pasture, other than woods pastured, includes less than 8 acres per farm, slightly more than half of which is tillable. The remaining farm area (see fig. 3), or 53.3 per cent of the total acreage, consists of woods and waste land. About one-fifth of the woods and waste land, or 11.4 per cent of the total farm area, either can not be brought under cultivation at all, or not without a large outlay, since it consists of roads, ponds, and swampy areas near the streams. A like area of the woodland is fenced and utilized as pasture, leaving exactly one-fifth of the farm area in woodland that could be cleared but is actually used only as a source of wood, lumber, and turpentine, and as a public range. The woodland, if fenced, furnishes a low-grade pasture which serves mainly to tide the live stock over the late winter, spring, and early summer period when the crop area as now organized does not provide sufficient pasturage. The unfenced woodland serves a like purpose, it being a common practice to allow cattle and hogs to graze the public roads and range. The woodland is covered for the most part with longleaf pine, some of which is being turpentine preparatory to lumbering and clearing, while more is held as a source of firewood and future lumber supply. Several turpentine stills and sawmills are in operation in the county.

TABLE II.—*Distribution of farm area (106 farms, Brooks County, Ga.).*

Total acres per farm.	Acres of crop land per farm.	Per cent of farm area in—					
		Crop land.	Woods pastured.	Other pasture.	Woods not pastured.	Waste, swamp, etc.	Total woods and waste.
331	145	43.9	11.4	2.8	30.5	11.4	53.3

DISTRIBUTION OF CAPITAL.

The average capital per farm and the manner in which that capital is distributed among its different elements are shown in figure 4. Three-fourths of the average farm capital consists of real estate, leaving one-fourth as working capital; and nearly three-fourths of

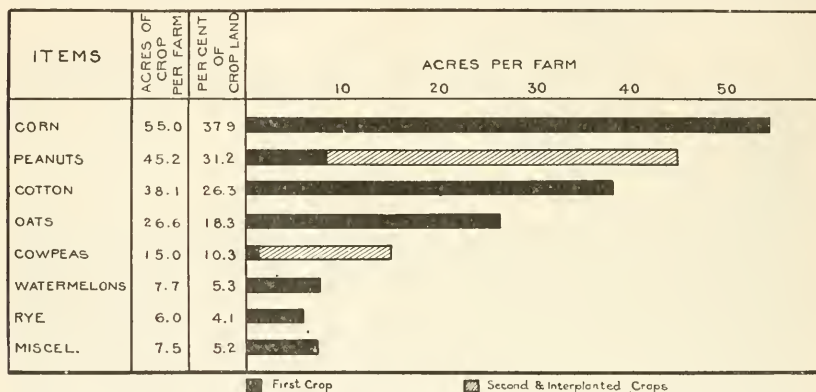


FIG. 5.—Acres of crops per farm.

the real estate value consists of land (\$4,970). The average dwelling is worth \$1,154, and the average values per farm of the tenants' houses and other buildings equal \$300 and \$364, respectively. Nearly half of the remaining investment consists of live stock, and more than 60 per cent of this is work stock. For every acre of land in crops, these farms had \$7.34 invested in live stock, \$4.66 in feeds and supplies, and \$2.28 in implements and machinery.

The average market price of the land of these farms was found to be \$20.50 per acre, while the crop land alone was valued at \$30.30 per acre and would rent for \$3.09. Thus the renting value amounts to approximately 10 per cent of the market value of the crop land. But it should be borne in mind that this rent is based on the land in its present state of fertility, which has been built up by the extensive growing and pasturing off of such crops as peanuts. If cropped for several successive seasons with cotton, this light, sandy soil would then rent for much less. A large part of the woodland other than waste is valued at but little less than the crop land, since it carries

merchantable timber that would pay for bringing the land into cultivation. Its value is included in the investment of the farm. While most of it gives but little or no direct return, and since it represents so large a proportion of the area, the inclusion of its value in the capital gives the farm a lower per cent return on the investment and a lower labor income than it otherwise would show.

CROPS.

The relative acreages of the principal crops grown on these farms are shown in figure 5. Corn represents the largest acreage, occupying 37.9 per cent of the whole crop area, while peanuts follow, with 31.2



FIG. 6.—Corn and peanuts are commonly planted in alternate rows. This is a sound practice (see page 54).

per cent; cotton comes third with 26.3 per cent; and oats fourth with 18.3 per cent. However, more than four-fifths of the acreage planted in peanuts consists of peanuts planted in corn, and hence is to that extent a duplication of the area reported in corn. Throughout this bulletin peanuts planted in corn are thus treated as a second crop. (See fig. 6.)

That cotton occupies a more important place on these farms than its relative acreage would indicate will be shown by a later table. Cowpeas for hay occupy fifth place in point of acreage, though this is nearly all a second crop, being planted after oats, rye, or watermelons. Watermelons come next with 5.3 per cent of the crop area, followed in importance by rye with 4.1 per cent. More than one-third of the rye acreage is grown wholly for grazing and as a winter cover crop, while other rye and much of the oats also furnish spring and winter pasture in addition to the grain harvested. The miscellaneous crops include sweet potatoes, sugar cane for sirup, sorghum, velvet beans, Irish potatoes, cucumbers, chufas, millet, and a few others. These miscellaneous crops occupy relatively unimportant

acres. However, they have an important place in the economy of the farm.

LIVE STOCK.

Brooks County has long been known for its live stock, particularly swine. The relative numbers of animal units¹ of the different classes of live stock found are shown in figure 7. Cattle constitute slightly more than half of the animal units, excluding work stock, while hogs make up more than nine-tenths of the remainder. Most of the farms keep a sufficient number of milk cows and poultry to supply the family needs, and in many cases a small surplus for sale on the local market; but on none of the farms is dairying or poultry raising otherwise important, owing to the limited local market for such products. A number of farms in the county make a practice of feeding cattle, securing some of the feeders from the other farms in this and in adjoining counties, and shipping others in from Florida. Three such farms are included in this survey.

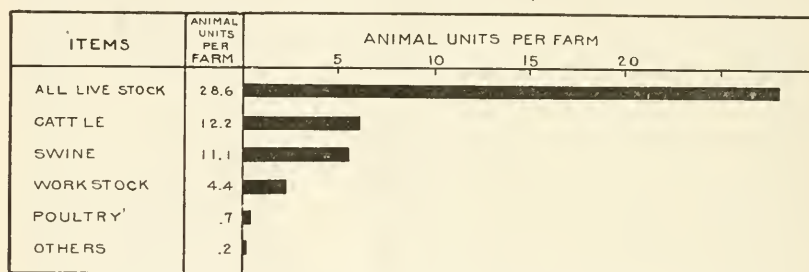


FIG. 7.—Number of animal units per farm of different classes of live stock

On a very few farms colts are grown, but nearly all the work stock is shipped in from other States. Bees are kept on a number of farms, but on only 4 farms studied were they an important source of income. One farm kept sheep and several supported a few goats.

The number of animal units of cattle carried slightly exceeds those of hogs, but the latter in reality occupy much the more important place in the business of these farms, as is brought out in Table III.

TABLE III.—Average value per animal unit of receipts from cattle, hogs, and poultry (106 farms, Brooks County, Ga.). Receipts include sales, increased inventories, and products consumed in the farm home.

Item.	Cattle.	Hogs.	Poultry.
Sales and increased inventory, per animal unit.....	\$9.68	\$37.60	\$42.25
Value of products consumed on farm, per animal unit.....	9.73	11.80	65.35
Total credits per animal unit.....	19.41	49.40	107.60
Total credits per hog unit ^a		9.88	

^a The equivalent of a 200-pound hog.

It will be seen that hogs gave returns amounting to two and a half times as much per animal unit as did the cattle, or \$49.40 as com-

¹ An animal unit is a mature cow or horse, or as many other animals as consume an equivalent amount of feed. Two colts or young stock, 5 hogs, 10 pigs, 7 sheep, or 100 poultry constitute this unit.

pared with \$19.41. Nearly half of the receipts from cattle consisted of dairy products sold and consumed in the home, the balance being mostly cattle sold on the hoof. The low receipts per animal unit from cattle are due to the low grade of most of the native stock kept, and to the presence of the cattle tick in the county when these records were taken. A strong effort is being made to eradicate the tick and to improve the breed of cattle kept. The hogs grown are mostly grade stock of fair to good quality.

SOURCES OF INCOME.

One means of measuring the importance of the different farm enterprises is by the receipts from each in the form of sales and increases in inventories. Figure 8 shows graphically the sources of farm receipts and the relative importance of each, measured by this standard. It is seen that cotton is by far the most important single source of income, furnishing half of all the farm receipts,¹ that term

¹ DEFINITIONS.—The terms defined below will be used frequently throughout this bulletin.

Farm receipts include all sales from the farm and increase of inventories of live stock, feeds, supplies.

Farm expenses include all current cash expenditures, the value of farm labor performed by the family (except the operator), depreciation on buildings and equipment, and decreases in inventories of live stock and feed and supplies.

Gross farm income is the sum of all farm sales, plus any increases in inventories. The *net farm income* is the difference between this sum and the sum of all farm expenses. For convenience, the term *farm income* is used to designate the net farm income.

Labor income is the sum that the operator has left for his own labor and management after deducting from the farm income the interest on his investment figured at the current rate on well-secured farm loans. In this study 8 per cent interest is the rate used. Frequently prices of land are influenced by factors other than the present earning power for farming purposes. In such cases it is better, when calculating labor income, to use the interest on the working capital plus the net rent from the real estate instead of the interest on the investment. In this study these two methods of calculation gave essentially the same result, hence the simpler one was used.

Farmer's earnings represent the sum of the labor income plus what the farm furnishes toward the living of the operator and all others living or boarding in the farm home.

Farm-management surveys have shown that the farm returns are largely dependent upon size of the business. For many purposes it is desirable that the factor of size be eliminated in order that farms of different sizes may be grouped together and compared. For this purpose the *index of earnings* is used herein. This factor is determined as follows: All farms of similar size are grouped together and the average farmer's earnings for each group is computed. The farmer's earnings of each farm in a given group is then compared with the average for that group, the group average being expressed as 100. Therefore, the index of earnings is the farmer's earnings expressed as a percentage of the farmer's earnings for all farms of a similar size. For example, if a farm shows an index of earnings of 110, it means that the farm in question returned farmer's earnings 10 per cent larger than did the average farm of a similar size.

The *per cent return on investment* is computed by deducting the value of the farmer's labor from the net farm income and dividing the remainder by the total capital invested. This figure expresses the profits of the business as that term is ordinarily used in the business world, and is nearly independent of the size of the farm. Obviously, this factor would have little value in comparing tenants with owner farms, but in this study all farms have been reduced to the same tenure, namely, that of owners who operate their own farms.

The per cent return on investment eliminates the factor of size even more completely than does the index of earnings. These two terms express the profits of the business from different points of view, one ascribing the profits to capital and the other to the operator's labor and management. Both having been found very useful in this study, and are the ones used throughout as the principal measures of farm efficiency.

as here used not including products consumed on the farm. Hogs furnish the next largest returns, with 15.7 per cent of the total receipts, followed by oats and rye taken together, watermelons, corn, and cattle, these ranging in order from 6.1 per cent to 4.4 per cent of all receipts. But when the value of the products consumed in the farm home is added to the sales, the order is changed, hogs taking second place followed by cattle, corn, miscellaneous crops, oats and rye, and watermelons. The miscellaneous crops include in order of importance sweet potatoes, peanuts, Irish potatoes, cabbage, etc. Other and less important sources of receipts or increases of inventories of feed and supplies are poultry and eggs, sugar-cane sirup (see fig. 9), cowpea hay, receipts from miscellaneous sources, and live stock other than cattle, hogs, and poultry. The last named con-

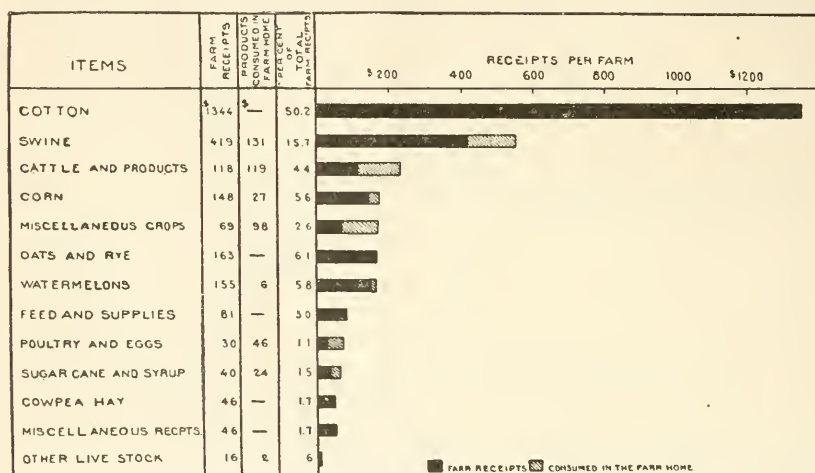


FIG. 8.—Sources of farm receipts and products consumed in the home.

sists of sales of honey and a very few colts, sheep, and goats. The miscellaneous receipts come from labor performed off of the farm, sales of wood, lumber and turpentine rights, tolls from gristmills, and rents from farm buildings, balers, and thrashing machines.

The value of swine products consumed in the farm home was found to equal nearly one-third as much as receipts from sales of such products. In the case of cattle, these two items were of almost identical value (see Table III), while the value of poultry products and of miscellaneous crops used on the farm greatly exceed the sales therefrom.

The method of measuring the size of any enterprise by direct receipts therefrom does not give the proper weight to the feed and pasture crops, the major part of which are consumed by the live stock on the farm. The total value of the crops grown is, for many purposes, a better measure, and when this measure is used the corn crop

ranks next to cotton, equaling half the value of that crop. The peanut crop then ranks fourth, and the oats, rye, hay, and sweet potato crops assume more importance than the receipts would indicate. A considerable part of the last-named crop is grown for hog pasture.



FIG. 9.—Grinding sugar cane and evaporating the sirup. Nearly every farm in this section grows a patch of sugar cane, and on many of the farms the sirup is a source of cash receipts.

CURRENT EXPENSES.

The current expenses include 82 per cent of the total farm expenses for the year if we do not consider the value of the operator's own service (\$405) as a farm expense. The remaining 18 per cent consists of depreciation of buildings, machinery, and work stock, and decreases in the inventories of live stock and feeds and supplies.

The amounts and the relative importance of the principal items of current expenses are shown in figure 10. Labor constitutes more than half of these expenses, and half of this labor expense consists of cropper labor (\$400). The latter represents the difference between the value of the cropper's share of the crops he produces and his expense for seed, fertilizer, and ginning, bagging, and ties. Wage labor equals 38 per cent of the labor expense, and the unpaid family labor makes up the remaining 12.5 per cent. Commercial fertilizers constitute slightly less than one-fifth of the current expenses, and feeds purchased less than one-twentieth. The three remaining important items of expense are, in order, repairs to buildings, fences, and machinery; ginning, bagging and ties; and taxes.

TENURE AND LANDLORD'S PROFITS.

Of the 106 farms included in this study, only 7 were operated by tenants. Of these, 5 paid a cash rent and 2 gave a stated amount of

lint cotton. However, 13 of the farm owners rented land in addition to the land owned, and 19 rented out parts of their farms, leaving 67 straight owner-operators. For these areas rented out a stated cotton rent or "standing" rent was the usual form of payment. No instances were found of entire farms rented for a share of the crop, though it is a common practice for single fields to be rented for a share of the crop grown, that crop usually being watermelons.

On 33 farms that were rented in whole or in part, and for which the rent paid was cash or "standing" rent, it was possible to calculate

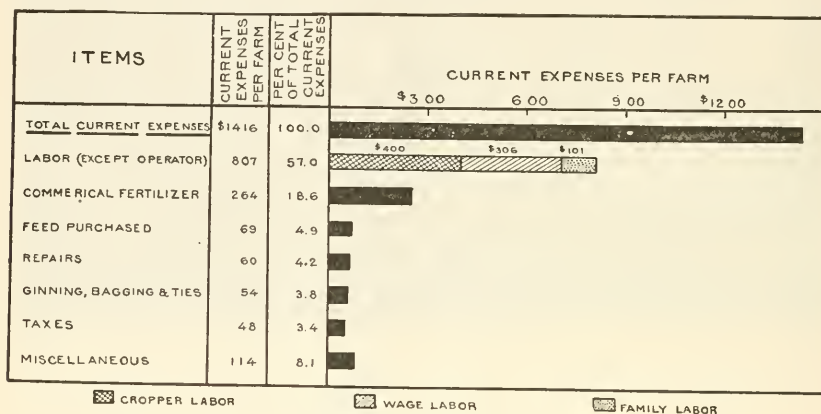


FIG. 10.—Items of current expenses.

the landlord's net return. After deducting taxes, depreciation on buildings and all other expenses, the landlord's net profit was found to be 8.25 per cent of the market price of the land.

Since so few tenant farms were found and it was desired to have all the farms on a common basis for comparison, all the farms rented in whole or in part were reduced to an owner-operator basis. This was done by adding the landlord's investment, receipts, and expenses to those of the operator, thus treating the operator as an owner. The parts of the farms that were rented out were eliminated from the farm business by deducting the investment, receipts, and expenses involved.

LABOR SYSTEMS.

WAGE SYSTEM.

Two distinct systems of hiring labor are found here, as throughout the cotton belt. One is the wage system and the other is the share cropper, or cropper, system. Usually the laborers hired by the month are contracted for in January for a period extending to the beginning of cotton picking. The usual monthly wage varies from \$10 to \$15 per month, with or without rations; besides which

usually a house and often a garden plot are furnished. Much labor is also hired by the day during certain seasons, and it is very common to hire by the "piece," the units being 100 pounds of cotton picked, an acre of crop "chopped" or hoed, a bushel of peanuts harvested or shelled, etc. Much of the day and "piece" work is done by women and children.

CROPPER SYSTEM.

Under the cropper system the laborer usually receives, in lieu of a cash wage, one-half share of crops he grows, and he is charged with half the cost of the fertilizer, ginning, bagging and ties, and sometimes half of the cost of seed used. The operator furnishes everything else, including work stock and all tools and equipment. In some cases the operator keeps all the cotton seed and in return does not charge the cropper for any of the fertilizer. Several other minor variations in the contract occur. In Brooks County the cropper is usually required to plant peanuts between the rows of the greater part of his corn. The peanut crop is almost always pastured off by hogs, only sufficient seed being gathered to replace that used for planting. In some instances the operator buys the cropper's share of the peanut pasture, but more commonly the cropper must have his own hogs to gather his crop if he is to profit by it.

By many persons the cropper is mistaken for a share tenant. But in this section, at least, he is regarded as a wage hand who receives his wages in the form of a share of the crop. He furnishes nothing but labor and is under practically as close supervision in the management of his crop as is the laborer employed for a fixed wage.

Most of the hired labor on these farms, both wage hands and croppers, are colored. Both labor systems are found on exactly half of the farms, including practically all the larger ones. The operator usually prefers the wage system and the laborer the cropper system. The reasons for these preferences will appear later in this discussion. The cropper is ordinarily considered to be a somewhat higher grade of laborer than is the wage hand.

Table IV shows the average cropper's receipts, expenses, and net income per cropper, cotton being figured at the average 5-year price, as it is throughout this publication.

TABLE IV.—*Cropper's receipts, expenses, and net income, per cropper on 53 farms (124 croppers, Brooks County, Ga.).*

Cropper's receipts:	
Cotton	\$297. 29
Corn and fodder	68. 74
Peanuts	19. 77
Other	2. 90
Total	\$388. 70
Cropper's expenses:	
Hired labor	13. 56
Family labor	60. 10
Interest on cash	7. 20
Fertilizer	36. 90
Ginning, bagging, and ties	11. 64
Seed, etc.	. 86
Total	130. 26
Cropper's net income ¹	258. 44
Estimated value of cropper's labor	138. 60

The average cropper's receipts amounted to \$388.70, and the average expenses to \$130.26, leaving a net income to the cropper for his labor upon his crops of \$258.44, which compares with \$138.60 as the amount that he would have received for the same labor had he been working for wages. In addition to this the cropper worked an average of 13.3 days for wages, most of it for the operator. Included in the list of expenses is an item of \$60.10, the estimated value of the labor of the cropper's family. This item added to the cropper's net income gives \$318.54 as the amount that the cropper and his family would have received for their year's work on their crops had cotton sold for a normal price. The difference between \$258.44 and \$138.60 represents the cropper's recompense for assuming a share of the risk of crop failure and a low market. All of the estimates upon which these calculations are based were secured from the operator and not from the cropper.

COMPARATIVE YIELDS AND COSTS BY WAGE AND BY CROPPER SYSTEM.

Table V shows the comparative yields and unit costs of crops grown by the systems just described. It will be seen that for each crop the average yields secured by the wage system are appreciably higher than those by the cropper system, the difference amounting to 16 per cent for cotton and solid corn and 8 per cent for corn planted with peanuts. These higher yields were undoubtedly due to heavier applications of fertilizer, closer supervision by the operator, and some differences in soil, since the best fields are often reserved for the wage crops.

¹ Does not include returns from labor other than on his own crop.

TABLE V.—*Comparative yields and unit cost of crops by wage and cropper systems (Brooks County, Ga.).*

Item.	Cotton.		Corn (solid).		Corn (with peanuts).		Peanuts (solid).		Peanuts (with corn).	
	Wage sys-tem.	Crop-per sys-tem.	Wage sys-tem.	Crop-per sys-tem.	Wage sys-tem.	Crop-per sys-tem.	Wage sys-tem.	Crop-per sys-tem.	Wage sys-tem.	Crop-per sys-tem.
Number of farms.....	93	53	47	14	77	43	49	4	76	42
Average yield of principal products.....	a 316	a 272	b 15	b 13	b 13	b 12	Pastured.		Pastured.	
Cost per unit of principal products:										
To cropper.....		\$0.00		\$0.48		\$0.38		\$2.56		\$1.74
To operator.....	\$0.093	.097	\$0.83	1.20	\$0.67	.93		7.53		.366
Average or total for system.....	.093	.089	.83	.84	.67	.66	11.09	10.09	5.70	5.40

a Pounds of lint.

b Bushels.

Under the wage system the average cost per pound of lint cotton is 9.3 cents, while under the cropper system the average cost to all parties concerned is 8.9 cents. But the share of the crop that goes to the operator costs the latter 9.7 cents a pound. From the standpoint of the laborer, the cropper system gives better financial results. This is as it should be, for the cropper assumes a part of the risk incident to production, which the wage hand does not. In case of partial or total crop failure the cropper loses the use of all or part of his time, while the wage hand receives the same, or nearly the same, income as in normal years.

In the case of corn, the total average cost is approximately the same by both systems, being 83 to 84 cents a bushel. But under the cropper system there is a wide divergence between the cost to cropper and operator of the share of the crop each receives. The cropper's share of the corn costs him only 48 cents a bushel (38 cents when interplanted with peanuts), while the operator's share of cropper corn costs the operator \$1.20 (93 cents with peanuts in the corn). This divergence is so great that it is not surprising that many operators who willingly accept share rent from croppers for cotton insist on cash rent for land devoted to corn, with the result that on cotton plantations generally a much larger proportion of corn than of cotton is grown under the wage system.

The major part of the operator's share of the cost of the cropper's crops consists of work stock, labor, and the use of the land. The details of these costs are shown in Table XX (see p. 52). It should be borne in mind throughout this publication that the term "costs" covers every charge, including cost of supervision and wages for the farmer, the cropper, and their families.

SIZE OF BUSINESS.

Farm-management surveys, this one included, have uniformly shown that the size of the farm business is probably the most important factor in determining the returns the farmer secures for his year's work. It is obviously impossible to secure a large return from a business of small volume, even if the margin of profit be a wide one. On the other hand, the larger the business the greater the possibility of both profits and losses. The influence of the size of the farm business on the returns is shown in Table VI. The sources and amounts of the farm receipts and expenses, and the net returns, presented from several different points of view, are shown for the groups of farms of different sizes and for the white and colored farmers separately.

TABLE VI.—*Relation of size of farm and race of operator to farm receipts, expenses, and net income (Brooks County, Ga.).*

Item.	Farms with total crop area of—					All farms.	All white operators.	All colored operators.
	Less than 50 acres.	50 to 74 acres.	75 to 149 acres.	150 to 249 acres.	250 acres and over.			
Number of farms.....	18	21	27	21	16	106	86	20
Acres of crop land per farm.....	33	63	111	192	389	145	166	54
Capital per farm.....	\$2,091	\$4,049	\$7,180	\$11,110	\$24,500	\$8,992	\$13,329	\$3,275
Receipts:								
Crops.....	\$413	\$845	\$1,420	\$2,560	\$5,527	\$1,964	\$2,213	\$896
Live stock (exclusive of work stock)....	101	185	460	931	1,482	584	702	80
Feed and supplies.....	35	39	92	99	155	81	87	53
Miscellaneous.....	11	23	70	14	118	46	49	31
Total receipts.....	560	1,092	2,042	3,601	7,282	2,675	3,051	1,060
Expenses:								
Current.....	\$232	\$541	\$996	\$1,846	\$4,195	\$1,416	\$1,639	\$453
Depreciation.....	44	88	124	172	325	142	158	73
Decrease feed and supplies.....	21	40	83	138	92	75	84	36
Decrease live stock (including work stock).....	37	63	71	114	198	90	101	42
Total expenses.....	334	732	1,274	2,270	4,810	1,723	1,982	601
Farm income.....	\$226	\$360	\$768	\$1,334	\$2,471	\$952	\$1,069	\$456
Interest at 8 per cent.....	167	324	575	888	1,959	720	826	262
Labor income.....	59	39	193	446	512	232	243	194
Food products used in home.....	267	377	479	544	612	453	507	228
Wood used by operator.....	12	14	14	16	18	15	15	14
House rent.....	33	53	98	133	306	116	132	40
Farmer's earnings.....	371	480	781	1,139	1,448	816	897	476
Estimated value family labor.....	\$61	\$118	\$98	\$119	\$102	\$101	\$88	\$159
Family earnings.....	432	598	882	1,258	1,550	917	985	635
Estimated value of operator's labor.....	\$153	\$270	\$372	\$442	\$900	\$405	\$446	\$231
Per cent return on investment <i>a</i>	4.4	4.6	6.4	8.9	6.7	6.2	6.2	6.2

a Unweighted averages.

It is seen that the average receipts, expenses, and net farm income (or farm income)¹ for the different groups vary in almost direct proportion to the size of the farm. The same is true of both the labor income and the farmer's earnings. Thus the farm income varies from \$226 for the smallest-farm size group to \$2,471 for the largest-farm group, giving an average of \$1,069 for all of the white farmers, \$456 for the colored, and \$952 for all the farms taken together. This figure represents the fund available for the living of the farmer and his family, provided he owns his farm unmortgaged, in addition to the unpaid family labor and the products furnished directly by the farm. This is of special interest to the unmortgaged farm owner.

When the earnings of the farm capital, or interest upon the value of the farm and equipment, is subtracted from the farm income, the difference is called labor income. This item varies among the different groups of farms from \$58 for the smallest farm to \$512 for the largest one, with an average of \$232 for all farms. The labor income is the measure of farm efficiency used in most farm-management surveys. It is of special concern to the tenant and the farmer who carries a mortgage. It must be remembered, however, that it does not take into account the living that the farmer and his family get directly from the farm.

When the items last named, consisting of food, fuel,² and house rent,³ are added to the labor income, the sum is what in this publication is called the farmer's earnings. This sum varies on these groups of farms from \$370 for the smallest farm size group to \$1,448 for the largest farm group, with averages of \$897, \$476, and \$816 for the white, colored, and all farms, respectively. The farmer's earnings are the measure of farm returns that has been used more than any other throughout this study.

The farmer's earnings do not include the value of the unpaid family labor. The latter averaged \$101, and when added to the former equals what is shown in the table as family earnings. This figure represents the value of all that the farmer and his family secure from the farm in addition to the interest on the farm investment. It is the amount that the tenant would have for a living for himself and family. The sum of this figure and the interest on the investment represents the total net returns that the unmortgaged farm owner and his family secure from his farm, the average amount of which varies from \$599 on the smallest farm group to \$3,509 on the largest farm group, and \$1,811, \$897, and \$1,637 for all white, all colored, and all farms, respectively.

¹ See definition in footnote, p. 13.

² Farm value of wood (uncut) used in the farm home. This does not include wood used by croppers and wage hands. However, the latter is included in labor costs in calculating costs of production.

³ Ten per cent of the present value of the dwelling (not the cost when new) is taken to cover the interest, taxes, and insurance.

A further study of Table VI shows that on the larger farms the operators live in much better houses and secure much greater values of food products from the farm than do those on the smaller farms. Between the extreme size groups the values of family food furnished by the farm varies from \$267 to \$612, and the average rental value of the houses from \$33 to \$306.

On the farms of the smallest farm group the value of family living obtained from the farm actually exceeded the net income from all other sources by 39 per cent, but on those of the largest farm group the family living furnished equaled only 38 per cent of all of the other net receipts. In other words, on the small farms the family living obtained is an all-important factor, while on the larger farms it is relatively a secondary consideration.

Another method of measuring the profits of the farm is to subtract the value of the farmer's labor from the farm income and call the remainder returns on the capital. Figured in this way, and not considering the item of family living obtained, these farms returned an average of 6.2 per cent on the investment. On the two groups of smaller farms the per cent returns were lowest, while on the fourth group, or good-sized family farms, they were highest.

QUALITY OF FARM BUSINESS.

CROP YIELDS.

On farms of a given size the yields secured constitute perhaps the most important factor in determining the farm profits. In Table VII the farms are grouped according to the average yield of crops. The group of farms that have the lowest yields have an average crop index¹ of 69, which means that the crop yields equaled but 69 per cent of the average yields secured by all of the farms. This group of farms returned average farmer's earnings² of \$586, while for the other groups the crop indexes were 92, 104, and 126, and the farmer's earnings \$708, \$840, and \$1,061, respectively. But the farmer's earnings are largely determined by the size of the farm. To eliminate the element of size and see the effect of crop yields independently, the index of earnings² and the per cent return on investment are shown. The group of farms with the lowest yields gave an index of earnings of 80, or in other words, farmer's earnings

¹The crop index represents the relative yields of all crops on any farm or group of farms as compared with the average yield of all crops on all the farms in the survey, the latter being expressed as 100. For method of calculating, see Department of Agriculture Bulletin 341, p. 75. The index here used is weighted, the acreage of each crop being weighted in proportion to the average amount of man labor expended on an acre of that crop. This weighting is necessary because of the wide difference in the relative intensity of the crops grown and of the different proportions in which these crops are combined on the different farms.

²See definitions in footnote, p. 13.

which equal but 80 per cent of the average farmer's earnings secured from farms of similar size. On the other groups of farms with increasing average crop yields, the index of earnings increased regularly to 116, while the corresponding returns on investment increased similarly from 2.9 per cent to 8.2 per cent.

TABLE VII.—*Relation of crop index to farm returns (Brooks County, Ga.).*

Crop index. ^a	Number of farms.	Average crop index.	Farmer's earnings.	Index of earnings.	Per cent return on investment.
Less than 0.80.....	13	69	\$586	80	2.9
0.80 to 0.99.....	43	92	708	87	5.6
1.00 to 1.09.....	21	104	840	108	6.7
1.10 and over.....	29	126	1,061	116	8.2
All farms.....	106	100	816	100	6.2

^a See definition of crop index on p. 22.

The close dependence of profits upon crop yields can be shown more concretely by considering for each crop separately the relation between costs and yields. This relation is shown by Table VIII.¹ In the case of every crop, as the yields increased the cost per unit of crop decreased regularly, while the profits per acre correspondingly increased. Thus, the cotton yields of less than 200 pounds per acre of net lint cost 11.6 cents per pound to produce, but this cost decreased to 7.5 cents per pound when the yields exceeded 400 pounds per acre. The low yields mentioned show a loss of \$1.63 per acre, while the high yields returned an acre profit of \$18.19. The farms that secured the higher yields of cotton were the ones which also returned the largest net profits for the year's business. Thus the farms that secured cotton yields of less than 200 pounds per acre returned farmers' earnings equal to only 47 per cent of the average returned by all farms of a similar size, whereas the farms yielding more than 400 pounds per acre returned earnings 37 per cent larger than the average.

¹ It will be noticed that the number of records for cotton and corn are greater than the number of farms surveyed. This is due to the fact that the costs of the wage crops have been kept separate from those of the croppers, since the two sets of crops are handled by more or less independent systems and are treated differently. Thus, many of the farms furnish two separate records of costs of cotton and corn. In this and one or two other tabulations these separate records have been treated as though coming from different farms.

TABLE VIII.—*Relation of crop yields to costs per crop unit and profits per acre (Brooks County, Ga.).*

Crop.	Yield.	Number of farms.	Average acre yield.	Cost per crop unit.	Profit or loss, per acre.
Cotton.....	Under 200 pounds.....	15	172	\$0.116	a—\$1.63
	200 to 299 pounds.....	68	258	.091	5.29
	300 to 399 pounds.....	43	338	.078	7.96
	400 and over.....	17	450	.075	18.19
	Average.....	143	299	.091	7.04
Corn, solid.....	Under 10 bushels.....	12	9.3	1.26	a—4.66
	10 to 15 bushels.....	33	13.4	.85	a—1.16
	16 to 20 bushels.....	11	17.8	.73	.15
	Over 20 bushels.....	5	24.2	.66	2.54
	Average.....	61	11.3	.89	a—1.31
Corn with peanuts.....	Under 10 bushels.....	18	8.2	.80	a—1.17
	10 to 12 bushels.....	37	10.1	.74	.04
	12 to 15 bushels.....	33	13.6	.70	.34
	Over 15 bushels.....	32	16.7	.57	2.92
	Average.....	120	12.4	.70	.82
Oats.....	Under 10 bushels.....	8	8.4	.84	a—2.53
	10 to 15 bushels.....	22	11.2	.73	a—1.68
	15 to 20 bushels.....	22	16.1	.47	1.21
	20 to 25 bushels.....	10	21.5	.37	3.42
	Over 25 bushels.....	8	27.9	.36	4.44
	Average.....	70	15.8	.56	.56
Cowpea hay.....	Under 0.5 ton.....	16	.34	26.88	a—1.74
	0.5 to 0.75 ton.....	37	.56	17.20	.68
	0.75 to 1 ton.....	5	.82	12.03	5.42
	1 ton and over.....	8	1.06	11.23	8.62
	Average.....	66	.59	18.57	1.42
Watermelons.....	Under 0.35 carload.....	5	.29	73.36	a—3.69
	0.35 to 0.49 carload.....	13	.42	53.68	1.84
	0.50 to 0.59 carload.....	17	.51	51.26	2.01
	0.60 and over.....	10	.70	41.60	15.08
	Average.....	45	.50	52.54	4.23
Sweet potatoes.....	Under 100 bushels.....	7	70	.36	14.18
	100 bushels.....	12	100	.28	27.27
	Over 100 bushels.....	7	162	.22	65.01
	Average.....	26	108	.29	33.90

a Loss.

These results would indicate that where the market prices and other conditions are similar to those found at the time these records were taken it is necessary to obtain a cotton yield greater than 200 pounds of net lint per acre if a profit is to be secured. But these records were taken before the cotton-boll weevil had invaded the county. With the expenses of fighting the weevil added, either yields higher than 200 pounds per acre, or prices higher than 10 cents per pound are necessary if the crop is to show a profit to the grower.

The data presented also indicate that under the conditions found, with corn at an average price of 75 cents per bushel, it is necessary to secure a yield above 10 bushels per acre of corn planted in rows alternating with peanuts, or about 18 bushels of corn planted "solid," if a profit is to be shown when figured by cost determination methods.

Similarly, oats must yield about 15 bushels to show a profit at an average price of approximately 50 cents; but when the yield slightly exceeds 25 bushels, the cost is reduced to 36 cents per bushel. The latter yields a good margin of profit.

Cowpea hay yielding one-third of a ton to the acre costs \$26.88 per ton to produce, and entailed a loss of \$1.74 per acre. Increasing the



FIG. 11.—Relation of yields of principal crops to cost per crop unit.

yield to one-half a ton brought the cost down to approximately the market price, and increasing it to slightly over a ton reduced the cost per ton to \$11.23 and resulted in an acre profit of \$8.62.

Watermelon yields of one-third of a carload per acre must bring about \$75 per car at the point of loading, if the grower is to "break

even." But if he increases this yield to half a carload he can sell for \$50 without loss, and if he further increases the production to two-thirds of a car per acre, \$40 per load will cover all costs.

All the yields of sweet potatoes found show a wide margin of profit. Average yields of 70 bushels per acre cost 36 cents per bushel; increasing the yield to 100 bushels reduced the cost to 28 cents, while a further increase to 162 bushels further reduced the cost to 22 cents. The records for this crop are few in number and represent small scale production. But the costs and margins shown would indicate that the crop offers commercial possibilities for the grower.

The manner in which the costs per crop unit decrease with increasing yields is shown for the six important crops by the curves in figure 11.

There is, of course, for each crop under any set of conditions a point beyond which any further increase in yield can be secured only at a cost per unit higher than the returns. On some individual farms in Brooks County this point of "diminishing returns" has no doubt been reached or exceeded; but these tabulations show that in no case have any of the groups of farms studied brought the crop yields to that point. Evidently one of the surest means of increasing the profitableness of these farms is the increasing of the crop yields.

UTILIZATION OF WORK-STOCK LABOR.

The largest item of cost, next to that of man labor, is the cost of work stock. In this study it was found to amount to \$509 per farm, which is approximately equal to half of the cost of all man labor, or 19.2 per cent of the cost of producing all farm crops. Figured on the basis of the cost per day of productive labor, the work stock cost \$1.07, as compared with \$1.20 for man labor. Manifestly, the utilization of work stock so as to keep down this large element of cost is one of the chief factors in determining profits on these farms.

TABLE IX.—*Relation of number of productive days mule labor per mule to farm returns, acres per mule, and cost of mule labor per day (Brooks County, Ga.).*

Productive days mule labor per mule.	Number of farms.	Average number of mule days per mule.	Cost of mule labor per day.
75 and less.....	12	62	\$1.70
76 to 100.....	26	88	1.23
101 to 125.....	33	112	1.00
126 to 150.....	21	137	.84
151 and over.....	14	172	.72
All farms.....	106	113	1.07

Increasing the amount of productive labor per mule reduces the cost per day of such labor, resulting in a lower cost of production and larger farm profits. This is shown by Table IX, in which the farms are grouped on the basis of the number of days of labor per mule. On the group of farms reporting the least productive labor per mule, or an average of 62 days per year, the cost per day of mule labor amounted to \$1.70, which daily cost decreased regularly to 72 cents on the group reporting the most labor, or 172 days per mule. The striking relation between increasing days' work per mule and decreasing cost per day of mule labor is shown by the curve in figure 12.

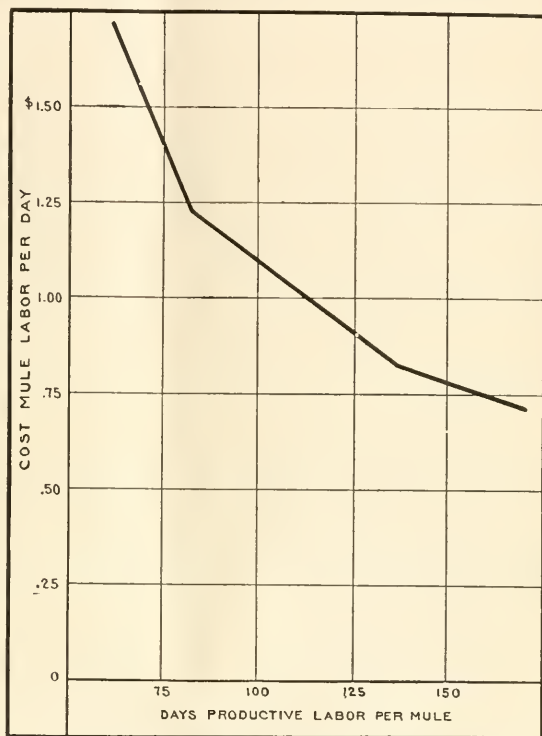


FIG. 12.—Relation of days of productive labor per mule to the cost per day.

It may well be asked by what means some of the farms provided so much more employment for the work stock than did others. The data in Table X indicate that the area cultivated per mule is the most important factor.

TABLE X.—Relation of number of acres of crop land per mule to utilization of mule labor and to farm returns (Brooks County, Ga.).

Number of acres crop land per mule.	Number of farms.	Average acres crop land per mule.	Acres of crop land per farm.	Acres of cotton per mule.	Days mule labor per mule.	Cost of cotton per pound.	Index of earnings.
Less than 20.....	11	16	48	5.1	67	\$0.095	80
20 to 24.9.....	18	22	81	7.8	89	.092	71
25 to 29.9.....	21	27	113	7.9	108	.092	103
30 to 34.9.....	24	32	144	9.0	121	.083	123
35 and over.....	32	42	233	9.4	139	.090	101
All farms.....	106	31	145	8.6	113	.090	100

Acres of crop land per mule.—In Table X the farms are grouped according to the amount of crop land worked per mule. The farms that have the fewest acres per mule, or an average of 16, secured only 67 days productive work from each animal, but as the number of acres increased, the number of days per mule increased regularly to an average of 139 on the group that operated the largest area per animal. This increased employment of the work stock resulted in a corresponding decrease in the cost per day of productive labor from \$1.50 to \$0.90. Such an economy in so important an item of cost must necessarily result in lower costs of production and greater profits. The cost of producing cotton decreased from 9½ cents per pound on the first-mentioned group of farms to 8.3 cents on the farms that operated 30 or 35 acres per mule, but it increased to 9 cents on the farms that had more than 35 acres per animal. This result was corroborated by the index of earnings, which increases markedly up to the point of 30 to 35 acres per mule. Beyond this the profits are less.

An apparent irregularity appears in that the index earnings were greater for the first than for the second group of farms shown in Table X. The explanation is that two or three farms with good crop yields and a low investment secured a high percentage of returns in spite of inadequate utilization of work stock. The number of farms in the group was insufficient fully to neutralize the influence of these few abnormal farms.

It will be noted that the farms which cultivated the fewest acres per mule average smaller in size than those which operated a larger area per animal. Undoubtedly the larger farms possess advantages which facilitate their organization upon a basis providing for the more efficient employment of work stock labor.

It may further be stated that the cultivation of an increased number of acres per work animal was not at the expense of crop yields. In fact, the lowest yields were found in the group that worked the smallest area per animal.

It is not probable that all the differences in costs and profits shown can be attributed to the differences in relative employment of work stock, for the men who keep their work stock efficiently employed are likely to be also more efficient in other respects. But the method of grouping used eliminates the effect of other factors as far as possible, and it is believed that the influence of area per mule has not been greatly overemphasized.

Farmers are often advised to reduce the number of acres per mule in order to cultivate the remaining acres more intensively, but the preceding table would seem to show that it is much more important to cultivate a sufficient number of acres per work animal to keep that

labor efficiently employed. From 30 to 35 acres per mule would seem to be the proper acreage under the conditions here found. The soil on these farms is a light sand and is easily cultivated. On a heavier type of soil, no doubt, fewer acres per mule would be found to be more desirable.

RELATION OF AMOUNT OF TILLAGE TO COSTS AND PROFITS.

Much has been said regarding the benefits arising from deep plowing, thorough and frequent preparation of the seedbed, and frequency of cultivation, much of the advice on these points making little or no distinction between types of soil. In gathering data for the purpose of calculating costs of production in this study, the amount of man and mule labor involved in each operation of each crop was ascertained for each farm. It is thus possible to study the profitableness of different amounts of tillage.

Using the amount of mule labor expended per acre as probably the best available measure of the degree of tillage, the effect of that factor upon the profits and costs of cotton have been tabulated and the results shown in Table XI. The cotton crop was used because it was the most important crop grown here and because for it the largest number of records are available. The figures upon which this table is based include all of the mule labor spent on the cotton up to and including the planting of the crop.

TABLE XI.—*Relation of amount of mule labor expended in preparatory tillage of cotton to costs and profits (Brooks County, Ga.).*

Days mule labor per acre, preparatory tillage.	Number of records.	Average mule days preparatory tillage.	Yield of net lint.	Profit per acre.	Cost of net lint per pound.
			<i>Pounds.</i>		
Less than 1.5.....	15	1.14	292	\$8.47	\$0.085
1.5 to 1.9.....	44	1.77	293	8.37	.087
2.0 to 2.4.....	51	2.22	298	6.53	.093
2.5 and over.....	33	2.89	311	6.22	.096
All records.....	143	2.12	299	7.04	.091

It will be seen that the increasing amounts of mule labor were accompanied by slowly increasing yields, but that these yields were not sufficient to offset the increased cost. Thus the cost per pound of net lint cotton increased regularly from 8.5 cents for the group that expended less than 1.5 days of mule labor per acre, to 9.6 cents for those on which more than 2.5 days were expended. These increased costs cut the profits per acre from \$8.47 to \$6.22.

The results shown in this table would indicate that the extra labor cost involved in the deeper and more prolonged preparatory tillage

of cotton is not profitable on the light, sandy soils of this area. A similar tabulation based on the total amount of mule labor expended on cotton up to the time of harvesting the crop gave similar results, though slightly less pronounced. The results in this case were less pronounced because there is less difference in the practices of cultivating the crop after planting than there is up to that time. Similar tabulations based on man labor gave less consistent results, since man labor is not so good a measure of the amount of tillage, owing to the differences in the number of mules used per team. No doubt different results would have been found on a heavier type of soil.

RELATION OF AMOUNT OF FERTILIZER APPLICATIONS TO YIELDS, COSTS, AND PROFITS.

To calculate the cost of production it was necessary to ascertain the cost per acre of the fertilizers applied to each crop. The data thus gotten permit an interesting study of the relative economy of the application of varying amounts of fertilizers on the principal crops. Using the cost per acre as a measure of the rate of application, since it is the only common measure for all of the fertilizer materials used, the effects on yields, costs, and profits have been tabulated for the principal crops, as shown in Table XII. The cost covers all classes of fertilizing materials applied, including stable manure, cottonseed meal, and commercial fertilizers, the last named representing the greater part of the costs. On none of the crops tabulated, except sweet potatoes, and possibly watermelons, was stable manure an important source of fertilizers. Approximately half the farms purchased the raw materials and did the mixing at home, while the others used ready-mixed fertilizers. No account has been taken of the residual effects of fertilizers applied to preceding crops, but these are reduced to a minimum in a region with such a light, sandy soil, heavy rainfall, and long growing season; and in any case they tend to neutralize each other when a group of farms are considered, as has been done in these tabulations.

TABLE XII.—*Relation of cost of fertilizer applications to yields, costs, and profits*
(*Brooks County, Ga.*).

Crop.	Cost of fertilizers per acre.	Number of records.	Average cost of fertilizer per acre.	Yield per acre.	Cost per crop unit.	Profit or loss per acre.
				<i>Pounds.</i>		
Cotton.....	\$2 and less.....	23	\$1.42	a 263	\$0.087	\$7.45
	\$2 to \$4.....	56	3.00	283	.088	8.00
	\$4 to \$6.....	35	4.85	293	.096	4.83
	\$6 to \$8.....	13	6.78	314	.101	4.18
	\$8 to \$10.....	9	8.76	383	.094	9.15
	\$10 and over.....	7	11.32	427	.086	11.00
	Average.....	143	4.32	299	.091	7.04

TABLE XII.—Relation of cost of fertilizer applications to yields, costs, and profits (Brooks County, Ga.)—Continued.

Crop.	Cost of fertilizers per acre.	Number of records.	Average cost of fertilizer per acre.	Yield per acre.	Cost per crop unit.	Profit or loss per acre.
Corn, solid.....				<i>Bushels.</i>		
	\$1.50 and less.....	28	\$0.70	13.4	\$0.85	a—\$0.79
	\$1.50 to \$2.50.....	22	1.89	14.1	.86	a— 1.02
	\$2.50 and over.....	11	4.19	16.7	1.03	a— 3.40
	Average.....	61	1.76	14.3	.89	a— 1.31
Corn, with peanuts.....	0.....	16	0	11.2	.57	1.72
	Under \$1.50.....	39	.97	11.5	.63	1.44
	\$1.50 to \$2.50.....	46	1.91	12.6	.74	.64
	\$2.50 and over.....	19	3.21	15.1	.94	a— .75
	Average.....	120	1.56	12.4	.70	.82
Oats.....	0.....	55	0	14.9	.55	.76
	Over 0.....	15	1.92	19.2	.61	a— .14
	Average.....	70	.41	15.8	.56	.56
Watermelons.....				<i>Carload.</i>		
	\$7 and less.....	16	5.86	.48	47.60	4.06
	\$7 to \$9.....	15	7.82	.50	50.48	2.96
	\$9 and over.....	14	9.80	.52	52.50	5.80
	Average.....	45	7.75	.50	52.54	4.23
Sweet potatoes.....				<i>Bushels.</i>		
	\$3 and less.....	7	1.93	85	.28	26.34
	\$3 to \$4.....	8	3.21	96	.30	26.78
	\$4 to \$7.....	5	5.12	113	.29	29.59
	\$7 and over.....	6	9.55	148	.30	53.83
	Average.....	26	4.70	108	.29	33.96

a Loss.

It was found that with every crop for which there were a sufficient number of records to make tabulations, increasing amounts of fertilizer resulted in regular and appreciable increases in yields. But with every crop except sweet potatoes the increased yields were obtained at a higher cost per unit of crop, with exceptions to be noted, and at lower profits per acre. Thus the cost of corn varied from 85 cents per bushel, with the least amount of fertilizer, to \$1.03, with the largest applications; the corn planted with peanuts cost 57 cents per bushel without fertilizer, which cost increased to 94 cents when the most fertilizer was applied. The profits per acre decreased in even greater proportion than the cost per bushel increased.

Cotton to which the value of the fertilizers applied amounted to less than \$2 per acre cost 8.7 cents per pound of net lint to produce. But with increasing amounts of fertilizer up to \$8 per acre, the cost increased to 10.1 cents per pound. Apparently, increasing the fertilizer applications beyond \$8 per acre reduced the cost below the high points of the preceding groups. But the small number of records for these highest applications renders the results unreliable for the last two groups.

Only 15 out of 70 farmers applied any fertilizer to the oat crop, a fact signifying that a large majority of them had not found it to be a profitable practice to make such applications. The 15 which did use fertilizers, to the extent of \$1.92 per acre, increased their yield, but in so doing the cost per bushel was increased from 55 cents to 61 cents, and a small profit per acre was turned into a slight loss.

Watermelons are fertilized rather heavily by nearly all growers, about 15 per cent of the value of the applications consisting of stable manure. The heavier applications resulted in somewhat increased yields, but at the expense of higher costs per unit of crop. Thus increasing amounts of fertilizers resulted in increasing the cost per carload from \$47.60 to \$50.48 and \$52.50, respectively. This increasing cost per carload resulted in a correspondingly reduced profit per acre in the case of the second group, but the last group offers an apparent exception in that it shows the largest profit in spite of the high cost per carload. The higher prices obtained for the melons receiving the most fertilizer were, no doubt, due to the resulting better quality of melons and to the fact that they matured earlier and reached a more profitable market than did the melons produced on the other farms. Better salesmanship may possibly have been a factor in securing the high prices.

The records for sweet-potato costs are few in number and represent only small-scale production. The fertilizers applied consisted largely of stable manure and cottonseed meal. The results are therefore not comparable to those obtained from records of other crops. The heavier applications were accompanied by much the higher yields, and the margin of profit was so wide in every case that the higher yields gave much greater profits, though the cost per bushel was nearly the same for all groups.

The conclusion to be drawn from this table would seem to be that on this type of soil, with the type of farming and the fertilizer practice found on these farms, it does not pay to use the larger amounts of commercial fertilizers on the common field crops. Watermelons may offer a possible exception, and sweet potatoes are distinctly exceptional. It should be remembered that on these farms the organic matter in the soil is largely maintained by the extensive growing and pasturing off of legumes, particularly peanuts. On a heavier type of soil different results would probably have been found.

ORGANIZATION.

DIVERSITY.

Much has been said and written regarding the advantages of a diversified type of farming. The greater safety from losses due to crop failure or demoralized markets, the better distribution of labor throughout the year, and still other benefits arising from diversifi-

cation have been repeatedly urged and are familiar to nearly everyone. Especially was the matter of diversity brought to the attention of the farmers of the South by the decline in the price of cotton following the outbreak of the European war. More particularly has the recent advent of the boll weevil into the southeastern part of the cotton belt increased the hazard of dependence upon cotton and made the matter an urgent one with farmers of that section. It is of peculiar interest, therefore, to study the farms of a locality where a distinctly diversified agriculture, with cotton as the most important source of income, has been practiced for a long term of years. Such an area is found in Brooks County, which has for years been noted for the extent of diversification practiced. This is particularly true of the southern half of the county, which is the area covered by this survey. It has been pointed out that the soil here is a light-gray sand, representative of the Norfolk sandy loam and closely related types of that series. On this light soil a certain degree of diversification, including the growing of legumes, is a necessity if soil fertility is to be maintained at a point where profitable yields may be secured. Necessity, thus, to a large extent, accounts for the development of the hog industry in this community. Further north in the county the soils become somewhat heavier, grading into the types represented by the Rustan and Tifton series. These latter are better adapted to cotton than are the lighter soils of the southern part of the county. As a result, cotton is grown there more largely to the exclusion of other crops.

To study the effect of different degrees of diversification upon profits, the farms studied have been grouped according to the degree of diversity practiced, the measure used being the diversity index.¹ The results are shown in Table XIII. The most highly diversified farms averaged the largest in size. Eliminating the effect of size by the use of the index of earnings, it is seen that the least diversification returned 15 per cent less than the average for farms of a similar size, while the most diversification returned 16 per cent more than the average. It thus appears that under conditions found on these farms, with market prices normal, greater diversity means greater profits. It should not be overlooked that the least diversified farms are largely cotton farms, which carry the risk of both low yields and low markets, a risk that in 1914 proved all but disastrous to these farmers.

¹On a farm with enterprises all of equal size, the number of enterprises will be the diversity index. For example, a farm with 4 enterprises, all of equal importance, would have a diversity index of 4. However, it is seldom that any two enterprises are of exactly the same size or importance. The method of calculating the diversity index, however, reduces all the enterprises to a comparable basis. For the method of calculating the index see Department of Agriculture Bulletin 341, p. 81.

TABLE XIII.—*Relation of diversity to cost of work-stock labor and to farm profits (Brooks County, Ga.).*

Diversity index.	Number of farms.	Average diversity index.	Acres of cropland per farm.	Cost of mule labor per day.	Crop index.	Index of earnings.
Less than 2.....	27	1.5	89	\$1.20	0.98	85
2 to 3.9.....	54	3.0	147	1.04	1.02	100
4 and over.....	25	4.7	194	.98	1.00	116
All farms.....	106	3.0	145	1.07	1.00	106

It is easily possible for diversification to be carried to an unprofitable extreme.¹ Beyond a not well-defined limit, further diversification may be at the expense of skill and attention to the details of the major sources of income. But it does not appear that any of these groups of farmers have gone beyond that limit.

Prominent among the advantages to be gained from diversification, increased crop yields, resulting from more frequent rotation, and better employment of labor throughout the year, are usually stressed. However, on these farms there appears to be but little relation between diversity and crop yields, the more diversified farms showing only a slightly higher crop index; but the diversified farms do show a distinctly better utilization of the work-stock labor, and it has been shown elsewhere that this factor is an important one. With the increase in diversity, the average number of days of productive work-stock labor per mule increased from 98 to 115 and 127, with resulting decreasing costs per day from \$1.20 to \$1.04 and \$0.98.

It thus appears that the more highly diversified farms have a slight advantage in yields of crops, and a considerable advantage in providing profitable employment for the work stock, and in returning larger profits per farm.

PRODUCTION OF HOME SUPPLIES.

Closely associated with the subject of diversification is the production on the farm of supplies consumed in the home. For many years the farmers of Brooks County have practiced, and prided themselves upon, the policy of producing at home a large part of the family living. In but few places will a class of farmers be found that produce for home use a larger amount of food products per family or per person than do the white farmers in this area.

¹ Department of Agriculture Bulletin 341, p. 82.

TABLE XIV.—*Relation of size of farm and labor of operator to value of food consumed in the home (Brooks County, Ga.).*

	Farms with total crop area of—					All farms.	All white operators.	All colored operators.
	Less than 50 acres.	50 to 74 acres.	75 to 149 acres.	150 to 249 acres.	250 acres and over.			
Number of farms.....	18	21	27	21	16	106	86	20
Number of adults per farm.....	3.7	5.0	6.0	5.8	5.7	5.3	5.5	5.1
Value of family food:								
Purchased.....	\$45.90	\$69.60	\$67.91	\$81.09	\$104.25	\$72.70	\$77.65	\$56.30
Produced on farm.....	266.90	375.71	479.10	543.60	611.69	453.29	506.59	228.30
Total per family.....	312.80	445.31	547.01	624.69	715.94	525.99	584.24	284.60
Total per person.....	84.54	89.06	91.17	107.70	125.60	99.25	106.22	55.80
Per cent of family food contributed by farm.....	85.	84.	88.	87.	85.	86.	87.	80.
Per cent of food grown on farm consisting of—								
Hog products.....	38.4	31.6	29.0	26.9	24.5	29.0	27.8	39.9
Poultry and eggs.....	7.6	9.1	9.9	11.8	11.0	10.2	10.7	6.2
Dairy products.....	19.3	23.9	26.2	25.7	32.0	26.2	27.4	14.6
Other live-stock products.....	1.1	.6	.2	.2	.2	.4	.4	.1
Total live-stock products.....	66.4	65.2	65.3	64.6	67.7	65.8	66.3	60.8
Fruits and nuts.....	2.9	4.4	5.4	7.8	4.2	5.2	5.5	2.7
Vegetables.....	15.3	18.2	17.0	17.8	18.5	17.6	17.7	16.7
Other products ^a	15.4	12.2	12.3	9.8	9.6	11.4	10.5	19.8
Per cent food contributed by farm is of the farmer's earnings.....	72	78	61	48	42	54	57	48

^a Corn meal and hominy, sirup,^ssugar cane, peanuts.

The total value per farm of that part of the family living furnished by the farm and the relation that this factor bears to the farm returns from other sources have been shown for farms of different size in Table VI. Further details of the values ¹ of family food, both purchased and grown at home, are given in Table XIV. Approximately 85 per cent of the family food consumed is furnished by the farm, and this proportion is substantially the same for all sizes of farms, though somewhat lower for the colored farmers. The figures show that there is a close relation between the size of the farm and the amount of food consumed, both per family and per person.² Thus, the average value of food consumed on the group of farms under 50 acres is \$312.80 per family, or \$84.54 per person, as compared with \$715.94 and \$125.60 on the farms of 250 acres and over. It will be seen further that the food supplied by the larger farms furnishes a more varied and better quality of diet than that on the smaller ones. In other words, the larger farms support a much higher standard of living as well as furnish larger net returns in other forms.

¹ The food values given are based upon the average prices on the farms and in the local markets, and are conservative.

² A person, as the term is used in this bulletin, means the equivalent of an adult fed in the farm home throughout the year. The number of adults per farm includes hired help and others boarded in the operator's home.

Two-thirds of the value of the food grown consists of animal products. On the small farms nearly two-thirds of the animal products come from swine, but as the farms increase in size dairy and poultry products find a more important place. Likewise, vegetables, fruits, and nuts are of more importance on the larger farms. Other products, consisting principally of corn meal and sirup, occupy a relatively more important place in the diet on the smaller farms.

By reference to figure 13 it is seen that swine products and dairy products each constitute more than one-fourth of the total value of family food furnished by the farm, while vegetables make up one-sixth of the total, miscellaneous products slightly more than one-tenth, poultry and eggs nearly a like amount, and fruit and nuts one-twentieth.

The quantities and the values per farm and per person are shown in detail in Table XV for each item of food, both purchased and furnished by the farm.

TABLE XV.—*Family food purchased and produced on the farm; amounts and values per family and per person (106 farms, Brooks County, Ga.).*

Kinds of food.	Unit.	Per family.		Per person. ^a	
		Quantity.	Value.	Quantity.	Value.
Purchased:					
Flour.....	Pounds.....	810	\$30.34	153	\$5.73
Sugar.....	do.....	191	13.37	36	2.52
Coffee, tea, cocoa, chocolate, postum.....	do.....		7.33		1.38
Rice.....	do.....	55	4.37	10	.83
Meat, lard, cheese, fish.....	do.....		2.60		.49
All other food.....			14.69		2.77
Total food purchased.....			72.70		13.72
Produced on farm:					
Pork.....	Pounds.....	770	108.40	145	20.47
Lard.....	do.....	185	23.00	35	4.34
Dairy products ^b	Gallons.....	471	118.50	89	22.36
Poultry.....	Number.....	69	24.50	13	4.62
Eggs.....	Dozens.....	111	21.90	21	4.13
Other live-stock products ^c			1.56		.29
Corn (meal and hominy) ^d	Bushels.....	27.4	27.40	5.2	5.17
Cane sirup.....	Gallons.....	38.6	15.50	7.3	2.92
Sugar cane.....	Stalks.....	524	8.02	99	1.51
Peanuts.....	Bushels.....	.86	.86	.16	.16
Pecans.....	Pounds.....	40.9	7.38	7.7	1.39
Sweet potatoes.....	Bushels.....	52.2	26.10	9.85	4.92
Irish potatoes.....	do.....	8.9	8.86	1.68	1.67
Beans and peas (green, in hulls) ^e	do.....	15.2	11.30	2.87	2.13
Turnips, rutabagas, and collards.....			6.80		1.28
Watermelons.....	Number.....	128	6.32	24.15	1.19
Tomatoes.....	Bushels.....	4.4	4.51	.83	.86
Cabbage.....	Heads.....	83	4.12	15.67	.78
Green corn.....	Bushels.....	3.8	3.83	.72	.72
Okra.....	do.....	2.6	2.60	.49	.49
Onions.....	do.....	1.6	1.80	.30	.34
Squash and pumpkins.....	do.....	2.0	.88	.38	.17
Cucumbers.....	do.....	.9	.87	.17	.16
Beets.....	do.....	.8	.83	.15	.16
Other vegetables.....			1.02		.19
Grapes (scuppernong).....	Bushels.....	3.9	4.70	.74	.89
Peaches.....	do.....	1.9	3.75	.36	.71
Figs.....	do.....	2.3	2.73	.43	.52
Pears.....	do.....	2.1	2.12	.40	.40
Oranges and grape fruit.....			1.77		.33
Apples and vinegar.....			1.33		.25
Total food produced.....			453.29		85.52

NOTE.—Values of food produced represent sale values on the farm.

^a Adult equivalent.

^b Milk, cream, and butter expressed as their equivalents in gallons of whole milk.

^c Honey, \$1.52; goats and kids, \$0.04.

^d Includes some corn bread and hominy fed to dogs and chickens.

^e Lima beans, snap beans, and cowpeas.

Of the food purchased, flour constitutes much the largest item, equaling 41.7 per cent of the total; sugar comes next with 18.4 per cent; the beverages (coffee, tea, cocoa, chocolate, postum) constitute 10.1 per cent; rice equals 6 per cent; and all other items make up the remaining 23.8 per cent.

Much has been said about the production of home supplies on the farm, and farmers are often urged to increase the proportion of the family food produced at home by growing more foods and buying less. But in this study it has been found that the ratio of food grown to that consumed is of less consequence than is the actual amount produced. However, in a tabulation made, but not presented here, there was found to be a certain relation between the percentage of family food produced at home and the farm returns as measured by

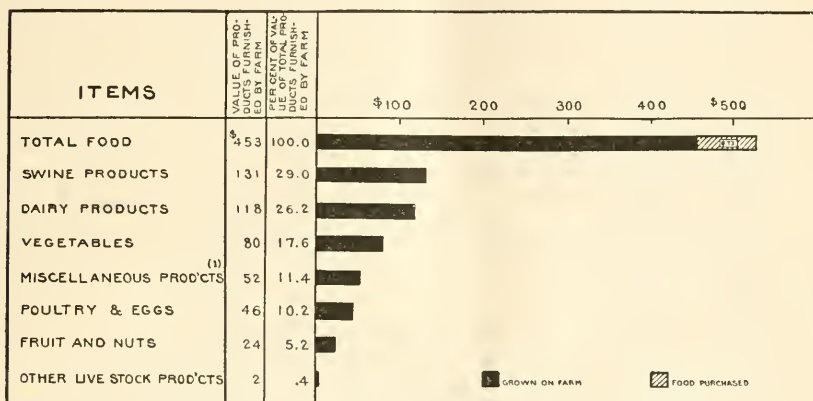


FIG. 13.—Value per farm of food products consumed in the home.

the farmer's earnings. Thus, the farmers growing less than 80 per cent of the food consumed had earnings 11 per cent lower than the average for farms of a similar size, while the similar return was 7 per cent above the average for those who produced more than 90 per cent of their own food. However, only 19 of the 106 farms fell in the former group, and only 28 in the latter, showing that the range of percentages was not so wide as would ordinarily be expected.

When the farms were grouped on the basis of the value of food grown at home the farmer's earnings and per cent return on the investment indicated considerably greater returns from the farms which furnished the more food. Thus, farms furnishing food to the value of less than \$250 each gave gross labor incomes 19 per cent below the average, while returns were 44 per cent above the average on the farms supplying more than \$600 worth of products.

When the farms were grouped on the amount of food furnished per person, tabulations showed much the higher returns from farms

supplying food to the value of from \$75 to \$100 per person than those furnishing either more or less than that range.

It would appear that the farmers who have produced the largest supply of family food at home have not thereby, on these farms, reduced the amount of food purchased. Rather, those who produced the most also purchased the most, since it is seen that the percentage of the total food bought is fairly constant. Those who produced the most food lived much better than those who produced less. The question of producing supplies at home seems, therefore, on these farms at least, to be not one of reducing the expense for purchased products, but it is rather one of a better standard of living.

CROPPING SYSTEMS.

In any region where economic conditions have been fairly uniform and operating over a considerable term of years, the type or types of agriculture tend to a stability of form that changes only in response to changes in the economic forces. Wide departures from practices that fit the economic factors at work are likely to lead to financial disaster to those persisting in them. The result is the automatic elimination of those continuing such wrong practices, and the eventual disappearance of the latter from the farming of the region. It will usually be found in an old established region that the average practices more or less closely approximate the best practice.

The proper selection of farm enterprises is a large factor in determining the success of the business. Of equal importance is the combining of these enterprises in the proportions that best fit the local conditions. Such a combination will be one that most efficiently employs the farm crew and equipment. Ordinarily, it will be one that distributes the labor, both man and work-stock, rather evenly throughout the year. But it is not to be assumed that under any set of conditions there is only one type of farming that may be safely followed, or that within the type there is not a certain range of choice in the selection of enterprises to be adopted and in the proportions in which these enterprises should be fitted together. In an area like Brooks County especially, with a growing season extending nearly throughout the year, and with a long list of crops adapted to the soil and climate, the choice is a rather wide one, largely dependent upon the abilities and inclinations of the individual farmer.

Much may be learned from a study of the average practices, and more especially of the practices which long experience has shown to be the ones best adapted to the region. This does not imply that the average practices are necessarily the best that could be devised. On the contrary, it will usually be found that they may be improved upon in important respects. Nevertheless, a study of the returns

secured when enterprises are combined in different proportions will help to show the proportions that are best adapted to the local conditions. Such a study has been made for the important crops found on the farms surveyed, and the results are presented in Table XVI. The index of earnings and the per cent returns on investment are the measures of efficiency used.

TABLE XVI.—*Relation of per cent of the crop area in specified crops to gross labor income and returns on investment (Brooks County, Ga.).*

Crop.	Per cent of crop land in specified crop.	Number of farms.	Average per cent crop land in specified crop.	Farmers' earnings.	Index of earnings.	Per cent return on investment.
Cotton.....	0.....	2	0	\$372	\$70	2.0
	0 to 10.....	10	7	553	90	3.2
	10 to 20.....	24	15	753	89	5.7
	20 to 30.....	25	25	1,112	128	7.7
	30 to 40.....	23	33	801	97	7.2
	40 and over.....	22	49	724	86	5.6
Corn.....	Under 30.....	19	26	852	93	6.4
	30 to 40.....	37	36	1,077	113	7.5
	40 to 50.....	24	44	756	92	5.9
	50 and over.....	26	57	474	92	4.8
Oats and rye.....	Under 5.....	22	2	635	92	7.9
	5 to 10.....	16	8	664	97	6.5
	10 to 20.....	27	15	872	112	6.9
	20 to 30.....	23	24	1,032	112	6.8
	30 and over.....	18	38	815	77	5.0
Cowpeas (for hay).....	Under 5.....	39	1	638	90	5.3
	5 to 10.....	17	8	907	104	5.5
	10 to 15.....	33	12	904	103	6.8
	15 and over.....	17	22	963	111	7.8
Watermelons.....	Under 5.....	64	.5	719	97	5.7
	5 to 10.....	21	7.0	999	103	6.8
	10 to 20.....	14	14.0	854	111	7.4
	20 and over.....	7	29.0	797	91	6.3

Reference to Table XVI will show that the farms with from 20 to 30 per cent, or an average of 25 per cent, of the crop land planted to cotton, gave higher returns than did those with either a larger or smaller proportion than this. Thus, the farms with no cotton planted returned farmers' earnings amounting to \$372. As the percentage of the crop land in cotton increased, up to 25 per cent, the farmers' earnings increased to \$1,112. But a further increase in the proportion of land in cotton resulted in lower earnings, amounting to \$724 for the group of farms with the largest proportion, or over 40 per cent of the land in cotton.

Expressed in another way, the farms with no cotton returned farmers' earnings amounting to but 70 per cent of the average of farms of a similar size. With increasing proportions of cotton planted, up to 25 per cent of the crop area, the returns increased to 28 per cent above the average, but decreased to 86 per cent with a still further increase in the proportion of cotton.

Measured in still another way, the "no-cotton" farms returned 2 per cent on the investment, while increasing the proportions of cotton gave increasing returns up to 7.7 per cent for the farms with one-fourth of the land in cotton. Further increase in the cotton area reduced the return to 5.6 per cent on the investment.

These results would indicate that where conditions are similar to those found on these farms at the time this survey was made, but with cotton figured at the normal 5-year price, the proper proportion of the crop land to be devoted to cotton to give the greatest farm profits is approximately one-fourth. Other farm-management surveys in the South have shown that in the areas represented more than one-fourth of the crop land should be planted to cotton to produce the largest profits. But such surveys have been made on types of soil heavier and better adapted to cotton than those in Brooks County. On such heavy soils, the maintenance of fertility by the growing of legumes, cover crops, etc., is not of such prime importance as it is on these lighter soils.

Corn is grown in Brooks County primarily as a feed for the live stock on the farm. However, a surplus is sold, the returns amounting to 5.6 per cent of the farm receipts. In a tabulation not shown, it was found that the farms getting from 1 to 5 per cent of the total receipts from the sale of corn were more profitable than those getting either a smaller or larger proportion from that source. This would indicate that sufficient corn should be planted to provide for all the farm needs. To insure this, a small margin of safety should be allowed, which will ordinarily mean a small surplus for sale. The proportion of land to be planted to corn, therefore, will be largely determined by the yield secured and the amount of live stock kept. The corn yields reported are rather low, but it should be remembered that the greater part of the corn grown is planted in alternate rows with peanuts. In considering, therefore, what area can profitably be devoted to this crop, due credit must be given to the pork produced by the accompanying peanut crop, as well as to the improvement in the soil fertility resulting from pasturing off the peanuts. The last-mentioned consideration is a very important one on these light soils.

In Table XVI tabulations similar to the one for cotton just discussed are also shown for the other important crops. The group of farms with from 30 to 40 per cent, or an average of 37 per cent, of the crop area in corn, gave considerably better returns, measured by both the farmers' earnings and return on the investment, than did those with either a greater or smaller proportion in that crop. This would indicate that approximately one-third of the crop area of these farms should be planted to corn. The cost-of-production data, to be discussed later, suggest that most of this corn should be grown with peanuts as an interplanted crop.

Oats are grown on these farms largely as a source of feed for live stock, especially work stock, as a winter cover crop, and to provide winter and spring pasture for hogs and cattle. It is also a source of cash sales, amounting on the average to 4.6 per cent of all farm receipts. On 25 of the farms the sales of this grain amounted to more than 5 per cent of the receipts. The cost records show that as a grain crop, oats, at the average yields obtained, returned but a narrow margin of profit, and the census data in the first part of this bulletin show that both the relative and actual acreage of the crop has been steadily decreasing in the county since 1880. Apparently it is not as a cash crop that oats should fill an important place on these farms, but rather as a source of farm feed and as a pasture and cover crop.

Referring again to Table XVI it is seen that the farms with from 10 to 30 per cent of the crop land in oats and rye together returned larger profits than did those with either a greater or a less proportion devoted to these crops.

Cowpeas are grown for hay on practically all these farms, and on one-third of them it is a source of cash sales. It is, in fact, the crop that furnishes the greater part of the hay grown. Approximately one-half of the acreage of oats and rye is followed by this crop, a proportion that is lower than that ordinarily found further north in the State. The lower proportion here is due to the heavy summer rains which often make the curing of this crop a difficult matter. The tabulation in Table XVI, however, indicates that the crop might with profit be grown more extensively than it is. The group of farms with the least of this crop planted returned the lowest profits, while the farms with the largest proportion of the crop land so planted got the highest returns.

The farms with from 10 to 20 per cent of the crop land planted to watermelons returned greater profits than did those with either more or less. However, this crop is a rather speculative one and too much dependence should not be placed upon such a tabulation.

Summarizing the results of the tabulations in Table XVI, it would seem that a cropping system adapted to the conditions on these farms at the time this survey was taken should divide the crop land approximately as follows: One-fourth to be planted to cotton, one-third to corn, 20 to 30 per cent in oats and rye to be followed by cowpea hay or a similar crop, and the balance to be planted to miscellaneous crops, the latter depending upon the individual tastes and inclinations of the farmer. The amount of oats, rye, and cowpeas to be grown should be governed by the amount of live stock kept. If many hogs are raised, most of the corn should be planted in alternate rows with peanuts, the latter to be hogged off.¹

¹ For a further discussion of the crops grown on these farms, see pp. 53-57.

The above percentages of the crop area in the different crops are very close to the average for all of the farms studied, though there is a wide range in the proportions found on the different farms. Likewise, when the 25 farms showing the best returns are selected, it is found that the crop areas are divided in proportions very closely approaching those found to be the most profitable in the above tabulation.

Elsewhere it has been pointed out that since this survey was made the cotton-boll weevil has invaded the county, and it can not be doubted that the proper organization of the farms has been to a large extent changed thereby. Whether or not the proportion of land in cotton found by this study to be most profitable will continue to be so under boll-weevil conditions can not be answered by the data at hand. It is certain, however, that the cost and hazard of growing the crop have been greatly increased, especially in this immediate section, where the mild winters and heavy summer rainfall favor the work of the weevil considerably more than do conditions even a short distance farther north in the State. In other infested areas with similar soil and climatic conditions, but where cotton has been more exclusively relied upon as the source of the farm income, a reduction in the proportion of land in cotton will likely be necessary. To the farmers in such areas, this study of the diversified farms of Brooks County should be of considerable value.

TABLE XVII.—*Relation of swine raising to farm profits (Brooks County, Ga.).*

Number of hogs per 100 acres crop land.	Number of farms.	Average number of hogs per 100 acres crop land.	Index of earnings.	Per cent return on investment.
Less than 20.....	19	18.8	92	5.1
20 to 40.....	42	32.4	94	5.1
40 to 60.....	26	50.3	97	7.0
60 and over.....	19	74.1	124	8.6
All farms.....	106	41.8	100	6.2

The presence of the boll weevil in the region of this survey must mean for many of the farmers a reduction in the proportion of the land planted to cotton. The question of what to substitute for the cotton displaced is a serious problem, a partial answer to which is found in Table XVII. The farms have here been grouped on the basis of the number of hogs kept per 100 acres of crop land. The group of farms with less than 20 hogs per 100 acres returned earnings equal to but 92 per cent of those from farms of a similar size, but as the number of hogs increased the returns increased. The farms with more than 60 hogs per 100 acres, or an average of 74.1, gave earnings 24 per cent higher than the average. Likewise, the

returns on the investment increased from 5.1 per cent for the farms with the lowest relative number of hogs to 8.6 per cent for the farms with the most hogs.

In another table, not shown, there was found to be a close and direct relation between the percentage of farm receipts obtained from hogs and the profits from the year's business. It should be borne in mind that these results were obtained before the advent of the boll weevil, and that the farms heavily stocked with hogs were not the ones that grew the largest proportion of cotton. In the presence of the weevil, hog raising should offer still greater relative advantages in the form of profits.



FIG. 14.—Brooks County has long been noted for its production of hogs, an enterprise that, since the invasion of the boll weevil, is partly, and profitably, replacing cotton.

These results would seem to indicate clearly that in the production of swine one of the most profitable substitutes for cotton is to be found. Since this survey was made, the production of hogs in this part of the State has been increasing at a remarkable rate. The problem of the proper organization of farms for the production of hogs in this area is the subject of a separate study. (See fig. 14.)

COST OF PRODUCTION.

Results obtained by cost accounting on the farm should not be given a too literal interpretation. It will frequently be found that cost-accounting methods indicate that certain farm enterprises are being conducted at a loss, but it does not necessarily follow that such enterprises should be abandoned. On the other hand, such enterprises may add materially to the profits from the year's business. It may be found, for example, on a farm devoted principally to

the growing of cotton that the production of corn and oats cost more than the market prices of these crops. But a large part of the equipment and man and mule labor that must be maintained for the growing of cotton is used also in producing the other crops, and much of this use is at a time when the equipment and labor are not needed for the primary crop. The additional expense incurred when corn or oats, in this instance, are added to the cropping system may be very much less than the amount of the costs charged to these crops by the usual cost-accounting methods. It may also be found that the secondary crops grown do not materially, if at all, reduce the amount of cotton that can be grown with a given crew and equipment. The cost of producing any of the usual farm crops, therefore, should be considered with a proper view to the farm or cropping system as a whole, rather than from the standpoint of an independent crop.

To determine the costs of producing farm products by means of daily cost-accounting records is slow and expensive. The present study is an attempt to secure by the much quicker survey method, applying well-established cost-accounting principles, the costs and other factors that are ordinarily obtained only by accounting. It is believed that the much larger number of records that may be secured by this method sufficiently neutralize any sacrifice in minute accuracy of details in individual records. The larger number of records that may be obtained greatly increases the number of problems that may be studied.

The essential feature of the method here used is that the overhead costs of the farm business are distributed among all of the productive enterprises¹ in proportion to the amount of labor expended on each. The total costs for the farm of man labor, work-stock labor, annual cost of equipment, and interest on the cash required to operate the business are determined separately. All other items of cost are charged directly to the enterprises to which they apply.

The total number of days of productive man labor expended on the farm for the year is determined. This total is divided into the total cost of man labor to ascertain the cost of each day of productive labor. To determine for any crop the acre cost of man labor, this cost per day is multiplied by the number of days of man labor expended on an acre of that crop. The per acre share of the interest

¹The term *productive enterprise* is used in this investigation to designate all crops, live stock, or other source of income that add directly or indirectly to the gross farm income. *Productive labor* of man or work stock includes all labor applied directly to a productive enterprise. It does not include such labor as repairing buildings, fences, terraces, and ditches, or the care of work stock. The amount of productive labor devoted to each enterprise was determined by individual estimates from each farmer, the estimates being made in detail by separate operations, and later reduced to terms of man days and mule days per acre of crop, or unit of other product.

on cash to operate the farm is determined in the same way. Likewise, the cost of work stock and of implements and machinery are distributed in a similar manner, but on the basis of the amount of mule labor expended on each enterprise. By this system the productive enterprises of the farm carry the entire overhead charge of the business. The costs of all crops grown by the wage system have been kept separate from the costs of those grown by the cropper system. For the latter the costs of the labor are considered from the point of view of the two parties to the system and not from that of the farm operator alone.

LAND RENT.

The land-rent charge against the crops was based upon the farmer's estimate of the amount that the crop land would return in the form of cash rent or its equivalent. When only a single crop occupied the land during the year, that crop bore the entire annual rent charge, and when more than one crop was grown the charge was in most cases divided evenly between them. However, in the case of corn and peanuts planted together, 63 per cent of the rent was charged to the corn and 37 per cent to the peanuts, for reasons explained later.

FERTILIZERS.¹

The fertilizer charge includes all commercial fertilizers, cottonseed, cottonseed meal, and stable manure applied. Stable manure is charged at the estimated value in the lot, which usually amounts to \$1 per load, and all other materials at the price paid or the market value. The costs of hauling from the shipping point and to the field are included under the labor charges.

MAN LABOR.²

Included in the man-labor charge are the cash wages paid and the value of rations furnished to all hired labor; the estimated value of the farmer's labor, the cropper's labor, and all family labor; as well as the perquisites furnished to each of these in the form of wood (uncut) and the renting value of the garden and house lot. It was assumed that the rent charge for the crop land covered the use of the buildings thereon. The relative and actual costs of the different elements of man labor are shown in figure 15, the figures given in every case including the perquisites. The cost of the operator's labor includes all supervision as well as the manual labor performed. All of the operator's labor charge against the cropper system consists of recompense for supervision. The cost given for cropper labor represents the amount that the croppers would receive in the form of wages for performing the same amount of labor. This differs from the item of cropper labor as given under current expenses. (See p. 16.)

¹ For a detailed discussion of fertilizers applied see pp. 30-32.

² For a discussion of the labor systems see pp. 16-19.

The operator's labor was the largest item in the total labor cost, equaling 38 per cent of the latter, followed in order by the cash-paid labor, the unpaid family labor, and the cropper labor. On the average, there were 926 days of productive labor expended per farm, of which 570 days were devoted to the wages crops and 356

LABOR	COST PER FARM	ENTIRE FARM				COST PER FARM	WAGE SYSTEM			COST PER FARM	CROPPER SYSTEM		
		\$100	200	300	\$400		\$100	200	\$300		\$100	200	\$300
OPERATOR	\$412					\$326				\$86			
CASH-PAID	328					312				16			
FAMILY	171					100				71			
CROPPER	172									172			
TOTAL	1083					738				345			

FIG. 15.—Cost of man labor per farm, for the farm as a whole, and for the wage and cropper systems separately.

days to the cropper crops. The average cost per day of the productive labor was \$1.20.¹

The man-labor charge was by far the largest item in the cost of producing crops, amounting to 40.4 per cent of the latter.

WORK-STOCK LABOR.

The second largest item in the cost of crop production is work-stock labor, which accounted for 19.2 per cent of the total cost. In calculating the cost of work-stock labor the items considered were feed, depreciation, interest on present value, shoeing, veterinary charges, and losses from injuries. It was assumed that the value of the manure produced was offset by the cost of water, taxes on the work stock, and interest, taxes, and insurance upon the feed. The labor of caring for work stock was considered as nonproductive; hence, by this system of cost determination, the cost of such labor is automatically distributed among all the productive enterprises on the farm. The stable charge is assumed to be covered by the rent of the crop land.

These farms maintained an average of 4.4 head of productive work stock, three-fourths of which consisted of mules. The average values at the beginning of the year were \$152 per mule and \$145 per horse, or an average of \$150 per head of work stock. The average cost of keeping a horse or mule for the year amounted to \$115.46, the items of which are shown in figure 16. Three-fourths of this cost consisted of feeds, and 59 per cent of the feed cost consisted of corn. Hay made up about 20 per cent of the feed cost, corn fodder 8 per cent, oats nearly 12 per cent, and all other feed 1.5 per cent. The latter consisted of green feed, mostly sorghum and pasture. Most of the oats were fed in the sheaf.

¹ Unweighted average.

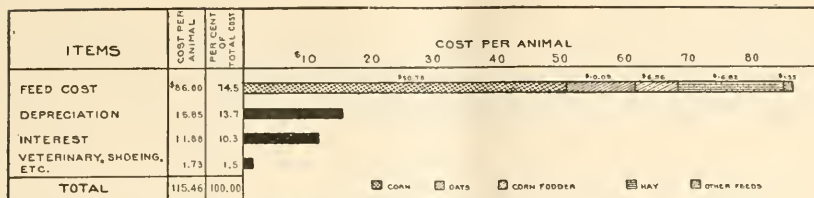


FIG. 16.—Annual cost of work stock per animal.

The depreciation on work stock accounted for 13.7 per cent of the annual cost, or 10.6 per cent of the average value per head. This means that the average remaining working life was 9.5 years.

With the average work animal on these farms, 31 acres of crop land were cultivated and 113 days of productive labor were performed, the latter at a cost of \$1.07¹ per day of such labor.

EQUIPMENT COST.

The present value of the implements and machinery on these farms amounted to \$330 per farm, or \$2.28 per acre of crop land. The annual charge against this equipment is the sum of the depreciation, repairs, interest, taxes, and insurance, minus the receipts from implements hired out. This charge, the items of which are shown in figure 17, amounted to \$103.47² per farm, or \$0.71 per acre of crop land. This sum equals 31.4 per cent of the present value of the equipment and 4 per cent of the total cost of crop production. As explained elsewhere, the equipment charge was distributed among the productive enterprises on the farm in proportion to the amounts of mule labor expended on each. The charge amounted to 21 cents for each day of productive mule labor.

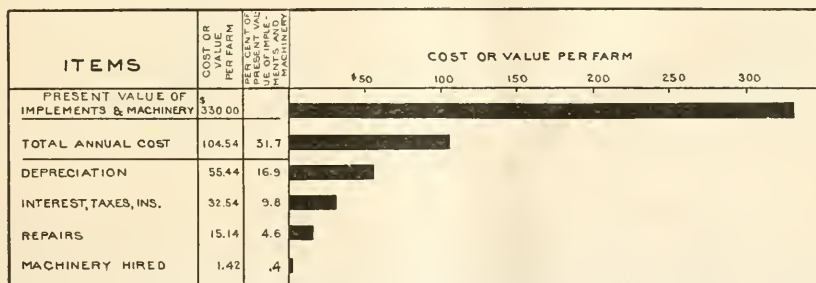


FIG. 17.—Present value and annual cost per farm of implements and machinery.

The item of depreciation includes more than half of the annual equipment cost, or 16.9 per cent of the present value of the imple-

¹ This cost is the average per day per farm, whereas the costs given in figure 16 are averages per animal.

² The total annual cost, \$104.54, shown in figure 17, represents the gross cost. Subtracting the receipts from machinery hired out, \$1.07, leaves \$103.47 as the net cost per farm.

ments and machinery. This means that in its present condition the equipment will have an average life of approximately six years. Interest, taxes, and insurance amount to about 10 per cent of the value of the equipment, and repairs slightly less than half of that amount.

PRODUCTIVE WORK UNITS.¹

For the purpose of distributing the labor costs among the different crops and other enterprises by the method here used, it was necessary to ascertain the amount of man and work-stock labor expended on each. This was determined for and applied to each enterprise on each farm separately. The average number of days of productive labor required per acre of each of the principal crops is given in Table XVIII. Since there is a close relation between crop yields and amount of labor required, the average yields are also shown.

TABLE XVIII.—*Productive days of man and mule labor expended per acre and average yields of the principal crops (Brooks County, Ga.).*

Crop.	Number of records.	Average days productive labor per acre.		Average yield per acre.
		Man labor.	Mule labor.	
Cotton, Upland <i>a</i>	143	13.91	5.03	299 pounds lint.
Cotton, Sea Island <i>a</i>	6	16.39	5.20	214 pounds lint.
Corn (solid).....	61	3.32	3.12	14.3 bushels.
Corn (planted with peanuts) <i>a</i>	120	2.50	2.00	71 pounds fodder.
				12.4 bushels.
				81 pounds fodder.
Peanuts harvested (solid).....	15	23.10	2.92	37 bushels.
Peanuts harvested (in corn).....	5	19.43	1.10	29 bushels.
Peanuts "hogged-off" (solid) <i>a</i>	53	3.33	2.67	(<i>b</i>)
Peanuts "hogged-off" (in corn) <i>a</i>	118	1.90	1.21	(<i>c</i>)
Oats.....	80	1.34	1.88	16.2 bushels.
Oat hay.....	15	1.50	1.70	831 pounds.
Rye.....	12	1.18	1.89	7.9 bushels.
Rye or oats, pastured.....	23	.55	1.12	
Cowpea hay.....	65	1.92	2.05	1,092 pounds.
Sorghum silage.....	4	6.72	6.80	14 tons.
Watermelons.....	46	5.36	5.00	0.5 carload.
Sweet potatoes (harvested).....	25	10.33	4.99	108 bushels.
Sweet potatoes (hogged-off).....	19	5.82	2.85	
Irish potatoes.....	4	5.88	3.82	69 bushels.
Sugar cane.....	24	26.24	14.40	307 gallons sirup.

a Includes both wage and cropper crops. *b* 0.71 bushel of seed picked. *c* 0.33 bushel of seed picked.

The relationships of the various elements of cost, yields, and other factors to the different phases of farm organization and efficiency have already been considered elsewhere. In the following pages, therefore, are presented only details of costs that have not been previously discussed.

¹ A work unit is an average day's work.

TABLE XIX.—Costs per acre and per unit of crops grown by wage system (Brooks County, Ga.).

	Cotton (Upland).	Cotton (Sealsland).	Corn (solid).	Corn (with peanuts).	Oats (thrashed).	Oats (fed in sheaf).	Rye.	Water- melons.	Sugar cane.	Sweet potatoes.
Number of records.....	91	3	47	77	49	31	12	46	15	25
Cost per acre:										
Land rent.....	\$3.05	\$3.00	\$2.86	\$1.90	\$2.09	\$2.17	\$2.08	\$2.93	\$3.45	\$3.22
Man labor.....	17.70	19.82	4.10	3.21	1.91	1.71	1.69	7.22	36.39	13.30
Mule labor.....	5.53	5.63	3.14	2.21	1.86	1.90	1.85	4.92	14.12	5.14
Implement cost.....	1.07	1.15	.63	.44	.38	.38	.38	.98	2.88	1.10
Interest on cash.....	.95	.68	.07	.06	.05	.03	.03	.15	.70	.21
Seed.....	.33	.23	.11	.07	.82	.84	1.42	.55	10.91	2.16
Fertilizer.....	4.76	4.11	1.88	1.46	6.46	8.3	.....	7.73	7.12	4.76
Special costs.....	61.62	62.40	.....	.....	6.15	8.07	6.08	6.40	66.41	.....
	.....	.....	.....	.....	6.96	.....	41.69	7.25	63.94	.....
	.....	.....	.....	.....	6.03	.....	.....	.22	.....	.....
Totals.....	34.51	37.02	12.79	9.35	8.71 f. 41	7.43 f. 03	8.62 f. 08	25.35 f. 26	85.92	29.89
Credits.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
Net acre costs.....	34.51	37.02	12.79	9.35	8.30	7.40	8.54	25.09	85.92	29.89
Value per acre.....	41.34	41.68	11.45	10.18	8.93	8.67	15.45	28.90	105.84	63.70
Profit per acre.....	6.83	4.66	k-1.34	.83	.63	1.27	6.91	3.81	19.92	33.81
Major product.....	Lint.	Lint.	Corn.	Corn.	Grain.	.....	.....	.....	.....	.....
Yield.....	7316	7228	m 11.6	m 12.7	m 17.5	m 11.2	m 7.86	6.5	Strap.	.....
Cost per unit.....	\$0.0928	\$0.137	\$0.83	\$0.67	\$6.47	\$0.52	\$1.09	\$30.18	6307	m 109
Minor product.....	Seed.	Seed.	Fodder.	Fodder.	Straw.	.....	.....	.....	\$0.24	\$0.28
Yield in pounds.....	7644	7611	762.9	779.1	723	.....	.....	.....	p Cane.	.....
Cost or value per ton.....	\$16.08	\$18.26	\$20.00	\$20.00	\$10.00	.....	.....	.....	.....	.....

TABLE XIX.—Costs per acre and per unit of crops grown by wage system (Brooks County, Ga.)—Continued.

	Irish potatoes.	Peanuts harvested.		Cowpea hay.		Oat hay.	Crops pastured.		Sweet potatoes.	
		Solid.	In corn.	Baled.	Not baled.		Peanuts.			Oats, rye.
							Solid.	In corn.		
Number of records.....	4	15	5	45	20	15	49	76	23	19
Cost per acre:										
Land rental.....	\$5.00	\$3.13	\$1.36	\$1.54	\$1.86	\$1.94	\$2.76	\$1.28	\$1.88	\$3.02
Man labor.....	6.76	27.50	28.03	2.78	2.21	1.75	4.57	2.39	.96	7.24
Mule labor.....	4.73	2.62	1.00	2.17	2.00	1.97	2.54	1.37	1.05	2.73
Implement cost.....	1.26	.96	.24	.49	.41	.35	.54	.26	.25	.66
Interest on cash.....	.20	.32	.26	.06	.10	.02	.08	.05	.01	.20
Seed.....	8.22	1.28	.92	2.02	2.28	.82	1.19	.88	1.43	1.64
Fertilizer.....	10.58	.80	.48	1.14	.44	.18	1.15	.07	.08	4.04
Special costs.....	9.62			4.28		4.02				
Totals.....	37.37	36.61	32.29	9.48	9.30	7.05	11.83	6.10	5.66	19.53
Credits.....					7.06		7.74	7.40	8.26	
Net acre costs.....	37.37	36.61	32.29	9.48	9.24	7.05	11.09	5.70	5.40	19.53
Value per acre.....	\$1.04	40.21	32.27	10.78	9.25	7.64				
Profit per acre.....	43.67	3.60	4.02	1.30	.01	.59				
Major product:										
Yield.....	m69	m37	m29	t57	t0.5	t0.42				
Cost per unit.....	\$0.55	\$0.99	\$1.12	\$16.72	\$18.58	\$16.37				
a Ginning, bagging and ties. b Twine. c Special car loader. d Barrels.	e Thrashing toll. f Car bedding. g Wood fuel. h Baling wire.	i Paper, nails, and slats. j Pasture. k Loss. l Pounds.	m Bushels. n Car. o Gallons. p Mainly seed cane.	q Sacks. r Seed picked. s Grain harvested. t Tons.						

All calculations of cost of crop production have been based upon an acre as the unit. In Table XIX the itemized acre costs, yields, values and profits, and the cost per unit of each product are shown in detail for all the important crops grown by the wage system; and the same data for the crops grown by the cropper system are given in Table XX, the costs to the cropper and to the farm operator being shown here separately. The cropper's share of the costs consists mainly of labor, that of himself and his family, and a small amount hired, followed in order by his share of the costs of fertilizer, gin-



FIG. 18.—For many years peanuts have been grown extensively in Brooks County, principally as a crop to be "hogged off". Only sufficient seed was harvested for planting purposes and a few cash sales. Nearly all of this was "picked" by the slow hand method here shown.

ning, bagging and ties, interest on cash, and planting seed. The operator's costs consist principally of mule labor, his own labor of supervision, land rent, and fertilizers, while of lesser and decreasing importance are the equipment cost, ginning, bagging and ties, seed, and interest on cash. The cost of the operator's supervision amounts to a little less than half as much as that of the manual labor, all of the latter being furnished by the cropper.¹

¹ The terms of the cropper's contract, the relative yields and costs to each party, and the relative yields and costs by the two systems are discussed in the first part of this bulletin.

COTTON.

Slightly more than half of the cost of producing cotton consists of man labor, followed in order by mule labor, fertilizer, and land rent.

The cost of growing cotton was divided between the lint and seed in proportion to the relative values of each. Substituting the average 5-year price of lint for the price received in 1914, for reasons previously explained, the value of the short staple lint was found to be 85 per cent of the total value of the lint and seed taken together. Therefore, 85 per cent of the cost of growing the crop was charged to the lint and 15 per cent to the cotton seed. The average cost of



FIG. 19.—Field of Spanish peanuts ready for thrashing. The recent high prices offered for peanuts by the oil mills have greatly stimulated the production of that crop for the market.

net lint¹ grown by the wage system is 9.3 cents per pound, which reduced to gross lint¹ equals 8.9 cents per pound. The cropper cotton costs 8.9 cents per pound of net lint to produce, which is equivalent to 8.5 cents per pound of gross lint. Since the cotton yield for the season of 1914 was somewhat higher than normal, these costs may be slightly lower than the average for a series of years.

In certain years a considerable acreage of Sea Island cotton is planted in Brooks County, but in 1914 the amount grown was comparatively unimportant. The number of records obtained are not sufficient to give a reliable average for this class of cotton, but the results are shown in the table for comparative purposes.

¹ By *gross lint* is meant the weight in the bale, including bagging and ties. By *net lint* is meant the gross lint minus the bagging and ties. Except where otherwise stated, the term "lint" is used throughout to denote net lint. The average weight of bales was 510 pounds, of which 23 pounds consisted of bagging and ties.

CORN AND PEANUTS.

Since corn and peanuts are commonly grown on the same land, the costs of these two crops will be considered together. Slightly more than two-thirds of the acreage of corn on these farms is planted in alternate rows with peanuts. Corn grown by itself, or "solid," is planted in rows usually 4.5 feet apart, but when the two crops are planted together the distance between the rows of corn is increased to 6 feet or more. There is some difference of opinion among the growers as to whether this widening of the rows results in the lowering of the yield of corn. The tabulated results, however, show that it does lower the yield to the extent of 15 per cent. But growing the



FIG. 20.—With the increased production of peanuts for the market many power "pickers" have been introduced. The straw is baled and used for feed.

two crops together results in distinct economies of labor and use of land, which much more than offsets the somewhat lower corn yield. Corn grown alone costs 83 cents per bushel to produce by the wage system, and 84 cents by the cropper system, whereas corn grown with peanuts cost 67 and 66 cents per bushel, respectively. An acre of peanuts in corn, it was found, costs approximately one-half as much as an acre of peanuts planted alone. These costs indicate that the local practice of growing the two crops together is an excellent one.

The costs of growing the two crops when planted together can not be divided on the basis of the respective values of each, since peanuts are nearly all pastured off, and as pasture they do not have a definitely measurable commercial value. Therefore, all costs that clearly could be charged to either of the crops separately were so entered. But the few mutual costs, such as the breaking of the land, and land

rent, which could not be directly separated, were divided between the two crops in the proportion of 63 per cent to the corn and 37 per cent to the peanuts. This division is based on the assumption that an acre of the combination crop is equal to 50 per cent of a full acre of peanuts and 85 per cent of an acre of corn. The ratio between these percentages is approximately 37 to 63. It is universally held by farmers in Brooks County that 2 acres of peanuts planted in alternate rows with corn are in every respect equal to 1 acre planted "solid"; and it was found that the corn yield when the two crops are planted together equals 85 per cent of the yield secured from corn planted alone.

Peanuts are grown on these farms primarily to furnish pasture for hogs, only sufficient seed being harvested to replace the seed planted and to furnish a small surplus for consumption in the home and for sale. The harvesting is therefore done on a small scale and hence is nearly all hand labor, resulting in a rather high cost of production for the peanuts picked. (See fig. 18.) Had harvesting been done on a scale sufficient to warrant the use of harvesting machinery, the cost per bushel would have been considerably lower than shown in the tables. When peanuts were gathered from areas used mainly for pasture, the value of the seed saved was deducted from the total cost and the remainder entered against the hogs as a pasture charge. Since this survey was made the increased market price for peanuts has greatly stimulated the production of this crop as a source of cash receipts. (See figs. 19 and 20.)

Only a part of the corn fodder produced on these farms is harvested, and that part represents such a small percentage of the value of the whole crop that it is here treated as a by-product, the value of the fodder gathered being deducted from the total cost of growing the crop, and the balance charged to the grain.

OATS.

Oats are grown on almost every farm as a source of feed for work stock, and on nearly half of them oats served as a source of revenue. On many they were grown for a winter cover crop and to furnish winter and spring pasture for hogs and cattle. Much of that fed to work stock is fed in the sheaf.

RYE.

Rye is grown on a considerable proportion of these farms, but mainly as a cover and pasture crop. On several farms the grain is harvested and sold locally for seed purposes. The yield is low but the price is high, nearly \$2 per bushel, resulting in a wide

margin of profit per bushel. As a grain crop, rye is very uncertain on this light, sandy soil, but it fills an important place as a cover and pasture crop.

COWPEA HAY.

Cowpeas are frequently difficult to cure for hay in this region, owing to rains during the period in which this crop matures. For this reason, the crop is not so commonly planted here as it is but a short distance farther north in the State. One-half of the area of oats and rye for grain is followed by a crop of cowpeas. One-third of the farms reported receipts from the sale of cowpea hay. The yield reported was low, averaging a little more than one-half ton to the acre. For purposes of determining costs, the crops baled were kept separated from those unbaled, the respective costs per ton of hay in the barn being \$16.72 and \$18.58. The difference in cost in favor of the crop bales was undoubtedly due largely to the difference in yields. Higher yields would unquestionably have given correspondingly lower costs per ton.

WATERMELONS.

Brooks County is in the center of an important area for the production of watermelons for shipping to northern markets, and on nearly half of the farms studied this crop is an important source of income. The fertilizer charge is the largest single item of cost, closely followed by that for man labor. It is usual for a professional car loader to pack the melons in the cars at a fixed rate per car. This cost is entered as "special carloader," instead of being included under costs of man labor. The material used for bedding the cars is mainly pine needles or oats or rye straw, the local value of which is nominal, and the cost of hauling which is included under the labor charges. The paper, nails, and slats charged are for lining and closing the cars. After the crop is harvested, cattle and hogs are usually allowed to graze off the cull melons and the growth of crab grass. The estimated value of such pasturage has been deducted from the gross cost as a pasture credit. Often a crop of cowpea hay follows the melons, in which case the former shares its proportionate part of the land-rent charge. The net cost of this crop amounts to \$25.09 per acre, or \$50.18 per carload. Nearly all the melons are bought on the loaded car at the shipping point, and the costs shown are figured at that point.

The average yield of half a carload per acre was normal, but the market price declined in the middle of the harvesting season to so low a point that a part of the crop was not gathered. The costs given in the table represent crops harvested and do not include the

cost of merchantable melons left in the field. When the cost is computed for the entire acreage of melons grown on the 46 farms, the cost per acre amounts to \$22.17, or \$58.32 per carload of melons harvested and sold.

SUGAR CANE.

Sugar cane is grown on every farm to produce sirup for home use, and on two-thirds of the farms it serves as a source of farm sales. The sirup is usually sold in barrels to the local merchants, who ship much of it out of the county. The average price received in the barrel during 1914 was 26 cents per gallon. The costs shown herein represent the cost of the growing of the crop, grinding, evaporating, and putting in barrels on the farm.

This crop is a very intensive one, requiring a large amount of labor per acre. Man labor is by far the largest item of cost, followed by mule labor, seed cane, and fertilizer. A considerable part of the latter consists of stable manure. The wood fuel used in evaporating the sirup is cut on the farms, and the labor of cutting and hauling the wood is included in the labor charges. The value of the seed cane saved and the small amount of canes sold or consumed on the farm has been deducted from the total cost, and the balance charged to the sirup, making the average cost 24 cents per gallon. The costs represent small scale production, but the profit per acre is fairly large. This crop can be grown at a comparatively low cost per unit of product, the chief problem being one of marketing the product.

SWEET POTATOES.

Sweet potatoes are grown in Brooks County only on a small scale, mainly for home consumption and for hog pasture. Nearly half of the cost of growing the crop is chargeable to man labor, the next largest items being mule labor, fertilizer, and land rent. The acre cost of the crop for hog pasture is \$19.53 as compared with \$29.89 for the crop harvested and put in the "banks," the difference being the cost of gathering. The average yield was 109 bushels and the cost per bushel 24 cents. These costs represent small scale production and not growing on a commercial basis. The margin of profit is wide and it would seem that the crop offers opportunities for commercial production, provided a market can be found for the product.

IRISH POTATOES.

Only four farms were found growing Irish potatoes primarily for marketing. The yield secured was 69 bushels per acre. The costs amounted to \$37.37 per acre and 55 cents per bushel in sacks on the farm. At the price received, about \$1.19 per bushel, the margin of profit is the widest found of any of the crops grown on these farms.

COST OF FEEDING CATTLE.

An increasing number of farmers in Brooks County are making a practice of fattening cattle for the market. Many of the feeders are shipped in from Florida. Others are purchased from farmers within the county or raised on the farms on which they are fed. Three such cattle feeders were included in the survey, and the itemized costs of feeding are shown in Table XXI.

TABLE XXI.—*Cost of feeding cattle on 3 farms (Brooks County, Ga.).*

Number of cattle fed, 378; number of pounds gained, 62,070.

Item.	Cost.
Man labor (208.5 days).....	\$345.31
Mule labor (323 days).....	292.91
Equipment cost.....	55.46
Cottonseed meal (140 tons).....	3,155.00
Cotton hulls (122.2 tons).....	625.00
Hay (3 tons).....	30.00
Silage (corn and sorghum) (132 tons).....	a 506.47
Pasture b.....	220.00
Bedding c (125 loads).....	30.00
Dipping, dehorning.....	27.00
Interest.....	327.31
Taxes.....	27.00
Gross cost.....	5,641.46
Manure credit (1,120 loads).....	1,120.00
Net cost of gains.....	4,524.46
Cost of cattle at beginning of feeding period.....	7,612.00
Cost of cattle at end of feeding period.....	12,136.46
Price received f. o. b. Quitman.....	12,091.00
Loss.....	45.46
Cost per 100 pounds of gain (weight at Quitman).....	7.29

a Charged at cost of production.

b 123 head for 2 months and 200 head for 3½ months.

c Oats, rye, and pine straw. Cost of hauling included under labor charges.

The 378 cattle fed gained 62,070 pounds, or 164 pounds per head, at a gross cost of \$9.09 per hundredweight. Deducting the value of the manure, estimated at \$1 per wagonload in the feed lot, gives a net cost of \$7.29 per hundredweight. On one farm the cattle gained 200 pounds per head, at a cost of 6.1 cents per pound, and returned a profit of \$1.74 each; on another the gains were 150 pounds per head, at a cost of 8.9 cents per pound, resulting in a loss of \$5.46 per head; while on the third farm the cattle gained 112 pounds each, at a cost per pound of 9.6 cents, and netted a loss per animal of \$5.66. The cattle were sold when the foot-and-mouth quarantine was in effect and the market depressed; hence normally a better showing in the matter of profits could be expected.

The cost of cottonseed meal and hulls constitutes nearly 84 per cent of the total feed cost. The silage fed is charged at the cost of production, since it has not here a recognized definite value. But all other feeds are charged at the prices on the farm or at the point of purchase. The labor charge includes the labor of buying the cattle, hauling feed from shipping point, feed and care of the cattle,

and marketing. The total costs are figured at f. o. b. the shipping point, Quitman.

COST OF SWINE PRODUCTION.

On 55 of the 106 farms surveyed hogs were raised in sufficient numbers to justify the calculations of cost of production. The itemized costs on these farms are shown graphically in figure 21, and in detail in Table XXII.

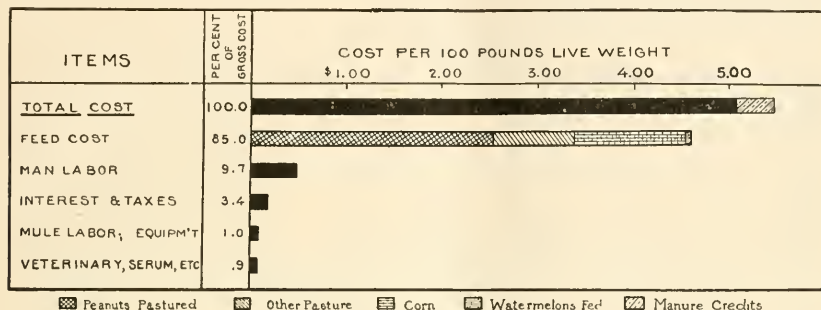


FIG. 21.—Cost of swine production.

It will be seen by the table that of the gross cost of producing hogs, one-half is accounted for by the cost of peanuts pastured, two-thirds by all crops pastured, and 85 per cent by all classes of feeds. The peanuts, oats, rye, and sweet potatoes fed were all pasture crops and have no definite commercial value, hence are charged at the cost of production. All other pasture is entered at the estimated renting value. Corn is charged at the farm price.

TABLE XXII.—Cost of swine production on 55 farms (Brooks County, Ga.).

Number of hog units *a* per farm, 77; pounds of live weight gains per farm, 11,033.

	Cost per farm.	Cost per 100 pounds live weight.	Per cent of gross cost.
Peanuts, pastured (32 acres) <i>b</i>	\$309.34	\$2.80	51.2
Oats and rye, pastured	26.03	.23	4.3
Sweet potatoes, pastured (2.24 acres) <i>b</i>	19.80	.18	3.3
Woods pasture	9.78	.09	1.6
Other pasture	10.70	.10	1.8
Total pasture cost	375.65	3.40	62.2
Corn (173 bushels)	129.40	1.17	21.4
Watermelons, fed	8.43	.08	1.4
Total feed cost	513.48	4.65	85.0
Man labor (41 days)	58.60	.53	9.7
Mule labor (5.1 days)	5.02	.05	.8
Equipment	1.13	.01	.2
Veterinary, serum, dips, medicine	5.50	.05	.9
Interest	19.62	.18	3.3
Taxes	.82	.01	.1
Gross cost	604.17	5.48	100.0
Manure credit	40.85	.37	6.8
Net cost	563.32	5.11	.....
Net cost on 45 farms with no losses from cholera		4.73	.....

a See footnote, p. 60, for definitions.

b Charged at cost of production.

Next to feeds, the largest item of cost is that of man labor, equaling nearly 10 per cent of the gross costs, followed by the interest charge, and others of minor importance. The average number of hog units¹ on each farm was 77 and the cost per pound of live-weight gain² was 5.1 cents. Ten of these 55 farms suffered losses from hog cholera, which, of course, increased the cost per pound of the remaining hogs. On the 45 farms free from such losses the average cost per pound was 4.7 cents.

The manure credit that has been deducted from the gross cost represents the estimated value of the residual fertilizing effect of the peanuts pastured off by the hogs. It is the consensus of opinion held by these farmers, based on experience, that the peanut crop grown and harvested from the soil is as severe a drain on soil fertility as is the growing of a crop of corn. Manifestly, then, any fertilizing value of peanuts "hogged off" is the value due to the method of harvesting, and as such should be a credit to the hogs and not to the peanuts. The average of a large number of estimates³ places this fertilizer value due to the method of harvesting at \$1.50 per acre of "solid" peanuts "hogged off," and at 75 cents per acre of peanuts and corn. Upon this basis the credits to the hogs have been calculated and entered as a manure credit.

Of special significance is the large proportion of the cost represented by pasture crops, especially peanuts. Undoubtedly herein lies the secret of profitable swine production in Brooks County.

Cost of slaughtering and curing swine.—It has long been the practice of the farmers of Brooks County to slaughter their hogs at home. Recently, however, a packing plant has been erected in an adjoining county, affording a ready market for live stock. Since the farmers now have the choice of selling their hogs on foot or of doing the slaughtering at home and marketing the resulting products, it is of interest to know the cost of killing and curing at home. These costs are shown in Table XXIII. On the farms that killed an average of 2,764 pounds of live hogs the cost amounted to 87 cents per hundred pounds of live weight, but on the farms that slaughtered 16,395 pounds each the cost was reduced by nearly one-half, or to

¹ A hog unit is a mature hog maintained on the farm during the year, or the equivalent of a 200-pound hog grown during the year. Immature hogs slaughtered or on hand at the end of the year were reduced to hog units by dividing the total live weight by 200 pounds.

² The live-weight gain includes the weight of all hogs sold and slaughtered, and any differences in the weights of all hogs on the farms at the beginning and ending of the farm year.

³ In getting these estimates the farmers were asked, first, how much more rent they would be willing to pay for the use of Brooks County land on which either peanuts or peanuts and corn had been grown the previous year than they would for similar land that had produced a crop of corn; second, how much less fertilizer, measured by value, they would apply to a crop of cotton planted on land that had produced peanuts or peanuts and corn than on land following corn. The replies gave a wide range of estimates, the average of which is given above.

46 cents per hundred pounds. The average cost was 54 cents. This does not include the marketing of the meat, but it does include the hauling of the ice, salt, etc., to the farm. It represents the cost of the meat cured ready to sell.

TABLE XXIII.—*Cost of killing and curing swine (Brooks County, Ga.).*

	Average of all farms.	Farms having each specified number of pounds of swine (live weight) killed per farm.			
		Less than 5,000 pounds.	5,000 to 7,000 pounds.	7,000 to 10,000 pounds.	10,000 pounds and over.
Number of farms.....	50	14	10	12	14
Average per farm:					
Live weight killed (pounds).....	8,438	2,764	5,446	8,266	16,395
Number of hogs killed.....	47.2	21	33.7	48	83
Average weight per hog killed (pounds).....	179	132	161	172	193
Man labor (days).....	18.01	10.1	13.5	20.3	27.1
Mule labor (days).....	1.57	.40	.82	1.4	3.5
Cost of man labor.....	\$23.51	\$13.58	\$15.20	\$26.70	\$36.65
Cost of mule labor.....	1.29	.43	.73	1.07	3.08
Equipment cost.....	.10	.03	.09	.14	.14
Building charge ^a	7.73	3.96	5.60	7.71	13.04
Salt.....	9.28	4.22	6.32	9.60	16.15
Borax.....	.43	.50	.57	.27	.40
Ice.....	3.10	1.22	1.08	3.11	6.40
Total cost.....	45.54	23.95	29.58	48.60	75.86
Cost per 100 pounds of live weight killed.....	0.54	0.87	0.54	0.59	0.46

^a Cold storage and smokehouses.

Approximately half the total costs consist of man labor. It is the usual practice to pay with scraps of the cheaper cuts of meats, the extra labor needed for killing. It should be borne in mind that a considerable part of the labor charge is the cost of supervision by the farmer, and that the slaughtering is done in January, at times when there is not much pressure of other work.

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UNITED STATES DEPARTMENT OF AGRICULTURE



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Contribution from the States Relations Service
A. C. TRUE, Director



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PROFESSIONAL PAPER

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EXPERIMENTS ON THE DIGESTIBILITY OF FISH.¹

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INTRODUCTION.

While many studies have been made of the digestibility of milk, cereals, fats, vegetables, and meats (especially beef), less information is available regarding the digestibility of fish. Slowzoff² has reported experiments with six persons in which fish was substituted for meat in an otherwise uniform diet to determine its effect on the metabolism of phosphorus, calcium, and magnesium. He found no change in the metabolism of phosphorus; the absorption of calcium was diminished 5 per cent, and the absorption of magnesium was increased 8 per cent. Kifanitsyn³ found that the protein supplied by salt cod was 90 per cent digested by human subjects when the fish was eaten alone and 94.4 per cent digested when eaten as a part of a mixed diet. Rozov,⁴ in a study of the relative digestibility of the fat of smoked and fresh smelt, found that it was 98 per cent utilized in the smoked and 97 per cent in the fresh. Slowzoff and Krawtschenko⁵ report

¹ Prepared under the direction of C. F. Langworthy, Chief, Office of Home Economics.

² Verhandl. Gesell. Russ. Arzte St. Petersburg., 76 (1909), p. 220.

³ Nutritive Value of the Cod. Diss., Imp. Mil. Med. Acad. [St. Petersburg.], 1887, pp. 56. [Russian.]

⁴ Comparative Assimilation of Fats from Fresh and Smoked Fish. Diss., Imp. Mil. Med. Acad. [St. Petersburg.], 1891, pp. 48. [Russian.]

⁵ Verhandl. Gesell. Russ. Arzte St. Petersburg., 1907-8; abs. in Zentbl. Gesam. Physiol. u. Path. Stoffwechsels, n. ser., 4 (1909), No. 1, p. 40.

NOTE.—This bulletin records studies of the digestibility of Boston mackerel, butterfish, grayfish, and salmon, and is primarily of interest to students and investigators of food problems.

that the absorption of mineral salts is better on a diet containing fresh or salt fish and poorer on a diet containing dried fish than on a diet containing beef. Van Slyke and White,¹ using the rate of excretion of nitrogen in the urine as an index of the rate of protein digestion, found that boiled cod (fresh) was more rapidly digested than boiled beef, boiled weakfish, boiled mussel, and boiled cod (salt). Rosenfeld,² in a study of the nutritive value of fish (sea pike and sea salmon), concludes that fish causes the excretion of a smaller amount of uric acid than meat and that fish is equal to beef for maintaining nitrogen equilibrium. In digestion experiments with beef and fish, Atwater³ compared the amounts of protein, fat, and ash assimilated, and obtained the same coefficients of digestibility for both food materials.

Studies of the digestibility of canned salmon have been reported by Milner,⁴ who found in four experiments in which an average of 401 grams of salmon was eaten daily for three days with a simple mixed basal ration consisting of bread, milk, butter, and sugar, that 96 per cent of the protein and 97 per cent of the fat of the salmon were retained by the body.

A number of other investigators have studied the value of fish flesh for food purposes by means of artificial digestion experiments. Hönigsberg⁵ studied the relative digestibility of fish and found that pepsin digested whitefish protein more rapidly than raw and less rapidly than cooked beef. In a study of the digestibility of fish protein by trypsin, White and Crozier⁶ found that boiled codfish and dogfish digested more readily than boiled beef. Sulima⁷ conducted experiments to determine whether there were differences in food in the raw state and that cooked at a high temperature which would affect the digestive process and concluded that gastric digestion was much slower with cooked than with uncooked fish (sardines). This difference, he believed, was due to the enzymes present in the raw fish. König and Spittgerber,⁸ as a result of determinations of the composition, energy value, and constants of fish fat, and a study of the digestibility of fish flesh by means of artificial digestion experiments, concluded that fish flesh is as easily and completely digested as meat.

In the earliest elaborate series of investigations of food materials made in this country, Atwater⁹ studied the composition of fish, and the results of this investigation contributed largely to the gen-

¹ Jour. Biol. Chem., 9 (1911), No. 3-4, pp. 219-229.

² Zentbl. Inn. Med., 27 (1906), No. 7, pp. 169-176.

³ Ztschr. Biol., 24 (1888), No. 1, pp. 16-28; abs. in Jahresber. Tier Chem., 17 (1887), p. 418.

⁴ Connecticut Storrs Sta. Rpt. 1905, p. 142.

⁵ Wiener Med. Bl., 5 (1882), Nos. 19, pp. 582-585; 20, pp. 614-616.

⁶ Jour. Amer. Chem. Soc., 33 (1911), No. 12, pp. 2042-2048.

⁷ Arch. Hyg., 75 (1912), No. 6-7, pp. 235-264.

⁸ Landw. Jahrb., 38 (1909), Sup. 4, pp. 1-169.

⁹ U. S. Comr. Fish and Fisheries Rpt. 1883, pp. 423-494.

eral knowledge of the food value of fish and its importance as a source of fat and other nutrients in the diet. The results of his studies¹ of 50 or more varieties showed that, on an average, fish contains over 18 per cent of protein, and about 4 per cent of fat. Generalizing from these data it has been pointed out² that fish may be divided on the basis of their fat content into three classes: Those with over 5 per cent fat such as shad, salmon, butterfish, and herring; those containing from 2 to 5 per cent fat such as whitefish, halibut, and porgy; and those containing less than 2 per cent fat such as bluefish, haddock, and cod. It is evident that fish, like meat, may contribute materially to the fat of the diet, particularly if the fatter varieties are eaten. On the basis of the protein they supply they also resemble meat, and this is true too with respect to the ways in which they are used in the diet. Accordingly, fish should be considered as a protein food and classed with the meats. However, notwithstanding the fact that protein is essential in the diet and fat is supplied in a readily assimilated form in fish, the use of fish is small in comparison with the use of beef, pork, and mutton, which are also sources of animal protein. The demand for land animal "meats" is at present in excess of the supply, while the possible supply of fish is believed to be much greater than the present demand.

In view of the attempts which are being made to interest the public in methods of reducing the consumption of meat without lessening the nutritive value and attractiveness of the diet, definite knowledge of the food value of fish is of especial importance. And so, as part of the studies of the food value and uses of fish in the home, which are being undertaken, it seemed desirable to study the digestibility of some varieties of fish taken to be representative of general types, including some which are well known and one, grayfish, which is comparatively new in the American market.

DIGESTION EXPERIMENTS WITH MEN.

Seven young men (medical and dental students) who had gained experience in other investigations of like character, served as subjects in this investigation. They were all normal individuals of good health, and reasonably active. During the experimental period they were requested to observe their usual routine as regards amount of exercise taken, hours of eating, etc. From their knowledge of physiology and previous experience in this type of work, they were sufficiently informed of the nature of their duties to appreciate the importance of carefully following the directions given them.

For the purpose of this investigation a special fore period and after period were not considered necessary, and accordingly the subjects

¹ Loc. cit. and U. S. Dept. Agr., Office Expt. Stas. Bul. 28 (1906), rev. ed., pp. 45-50.

² U. S. Dept. Agr., Farmers' Bul. 85 (1898), p. 14.

were allowed to follow their customary dietary routine preceding and following the experimental period. For the purpose of identifying the feces of the experimental period, three or four gelatin capsules containing about 0.3 gram of pulverized charcoal were taken with the first meal of the experimental period and with the first meal following it; the separation of the feces due to the diet under investigation was easily made at the lines of demarcation made by the portions dully colored by the charcoal.

Inasmuch as this study is concerned principally with the coefficient of digestibility of the protein and fat of the fish, no attempt was made to maintain a nitrogen equilibrium or uniform body weight of the subjects. The urine resulting from the experimental periods was not collected, for it was considered that any constituents of the foods which had been sufficiently broken down to appear in the urine had undergone the process of digestion; furthermore, the results obtained by collecting and analyzing the urine of a short test period are not entirely conclusive since the urine can not be separated as satisfactorily as the feces.

PREPARATION OF FISH.

In this study of the digestibility of different types of fish, fresh butterfish and Boston mackerel were used, and canned grayfish and canned salmon. A fish loaf seemed to be the best form in which to prepare the fish for eating, since sufficient quantities for the entire experimental period could be prepared at one time. Furthermore, it was easy to prepare a fish loaf having a uniform composition and one which would not change materially on standing by the settling out of fat or evaporation of water.

The butterfish and mackerel received a preliminary cooking before being incorporated in the fish loaf. The fish, after being cleaned, were thoroughly washed and placed as close as possible to each other in a covered cooker, water was added, and they were cooked for one-half hour. They were not boiled, but steamed in a very small quantity of water which prevented browning or sticking to the pan. To prevent any loss due to extracted fat and protein, the water in which the fish were steamed was retained and mixed with the fish meat, Beythien¹ having reported that the water in which fish were boiled contained 8.8 to 11.3 per cent of the total fish protein. After this preliminary cooking of the butterfish and mackerel, the bones, any pieces of fins, etc., were removed and the fish meat was cut in an ordinary household meat cutter. The bones and bits of skin were removed from the canned grayfish and salmon, and the solid meat was minced in a meat cutter. From this point the prepa-

¹ Pharm. Centralhalle, 47 (1906), p. 140.

ration of the fish loaf was identical for the canned and fresh fish. In each instance a quantity of the fish to be studied sufficient for the entire test period, after being mixed with salt and pepper, was very thoroughly and uniformly mixed and baked for two to three hours in a moderate oven. Whatever crust formed during baking was removed, and the remaining portion was again thoroughly mixed in order to secure a uniform product, after which a sample was taken for analysis.

NATURE OF THE DIET.

Inasmuch as experience has shown that in studying the digestibility of a single food it is desirable to supply the food material under consideration as a part of a simple mixed diet, a suitable basal ration was served with the fish loaf. It consisted of boiled potatoes, crackers, apple sauce, sugar, tea or coffee, and a little lemon juice as a condiment in some cases. In accordance with the usual custom, a sufficient supply of the special food under consideration (fish loaf) and of the other foods was prepared in advance for the whole experimental period. The fish loaf was kept in a refrigerator at 15° C. and remained fresh and in good condition, as did also the potatoes, which were boiled, mashed, and thoroughly mixed to insure uniform composition. The apples, which were eaten raw, were of good grade and pleasant flavor. The crackers or "biscuits" used were taken from a large lot and assumed to be of uniform composition. Though no attempt was made to have all eat like amounts, the subjects were urged to eat liberally of the fish loaf and moderately of the crackers and potatoes, following their individual preferences with respect to the apples and the tea or coffee.

As a whole, the ration, though it contained no added fat and only moderate amounts of carbohydrates, was reasonably generous as regards protein and energy and was varied enough not to become tiresome.

The food for each man for each meal was weighed in advance and kept separate. All remaining uneaten was weighed. The difference between the amount furnished and the amount remaining represented the amount eaten.

Samples of the food were reserved for analysis. The small amount of lemon juice (on an average, 35 grams per day), which was eaten with the butterfish and the Boston mackerel, was disregarded in computing the food value of the diet.

The feces were collected, sampled, and analyzed by the methods followed in the department's digestion experiments, of which the present investigation forms a part.¹

¹ U. S. Dept. Agr. Bul. 310 (1915), pp. 23. See list on last page.

BOSTON MACKEREL.

The investigations reported in this paper, which form a part of an extended study of the digestibility, nutritive value, and uses in the home of fish and fish products, have to do particularly with the digestibility of protein. One of the varieties of fish, Boston mackerel, here studied in comparison with other sorts of fish, has, however, been considered from the standpoint of the relative digestibility of animal fats of different kinds in an earlier bulletin.¹

Boston mackerel (*Scomber scombrus*, Linnæus) is a highly flavored fish, which can be compared to moderately fat meat in food value, since it supplies good amounts of both protein and fat. This fish, which is found throughout the north Atlantic, spends the winter months in deep water; in the spring, schools rise to the surface and approach the land. This fish forms one of the chief products of the New England fisheries, the catch during the year 1916 amounting to approximately 16,000,000 pounds. The fish used in this investigation were purchased at a local market and weighed, after cleaning, approximately 3 pounds each. They were procured at the height of the season, were in prime condition, and when prepared in the form of a fish loaf made a most appetizing dish. While the Boston mackerel possesses a characteristic flavor which is quite pronounced in the boiled or fried fish, this flavor was not evident in the fish loaf.

Three subjects living under normal conditions, who had acquired considerable experience in work of this kind in connection with the determination of the digestibility of some of the common edible fats of animal and vegetable origin, assisted in this study. The results which were obtained in the three-day test period follow.

¹ U. S. Dept. Agr. Bul. 507 (1917), p. 16.

Data of digestion experiments with Boston mackerel in a simple mixed diet.

Experiment, subject, and diet.	Weight of food.	Constituents of foods.				
		Water.	Protein.	Fat.	Carbohy- drates.	Ash.
Experiment No. 444, subject D. G. G.:	<i>Grams.</i>	<i>Grams.</i>	<i>Grams.</i>	<i>Grams.</i>	<i>Grams.</i>	<i>Grams.</i>
Boston mackerel (in form of fish loaf).....	1,496.0	926.0	323.0	199.9	.....	47.1
Potato.....	439.0	331.5	11.0	.4	91.7	4.4
Crackers.....	284.0	19.6	23.0	38.0	201.1	2.3
Fruit.....	1,320.0	1,116.7	5.3	6.6	187.4	4.0
Sugar.....	171.0	.....	.....	.....	171.0	.....
Total food consumed.....	3,710.0	2,393.8	362.3	244.9	651.2	57.8
Feces.....	67.0	.....	19.3	10.1	31.9	5.7
Amount utilized.....	.....	.....	343.0	234.8	619.3	52.1
Per cent utilized.....	.....	.....	94.7	95.9	95.1	90.1
Experiment No. 446, subject R. L. S.:						
Boston mackerel (in form of fish loaf).....	1,184.0	732.9	255.6	158.2	.....	37.3
Potato.....	227.0	171.4	5.7	.2	47.4	2.3
Crackers.....	243.0	16.8	19.7	32.6	172.0	1.9
Fruit.....	1,376.0	1,164.1	5.5	6.9	195.4	4.1
Sugar.....	58.0	.....	.....	.....	58.0	.....
Total food consumed.....	3,088.0	2,085.2	286.5	197.9	472.8	45.6
Feces.....	53.0	.....	21.9	7.5	16.2	7.4
Amount utilized.....	.....	.....	264.6	190.4	456.6	38.2
Per cent utilized.....	.....	.....	92.4	96.2	96.6	83.8
Experiment No. 447, subject O. E. S.:						
Boston mackerel (in form of fish loaf).....	1,348.0	834.4	291.0	180.1	.....	42.5
Potato.....	476.0	359.4	11.9	.5	99.5	4.7
Crackers.....	171.0	11.8	13.8	22.9	121.1	1.4
Fruit.....	1,594.0	1,348.5	6.4	8.0	226.3	4.8
Sugar.....	165.0	.....	.....	.....	165.0	.....
Total food consumed.....	3,754.0	2,554.1	323.1	211.5	611.9	53.4
Feces.....	70.0	.....	28.6	12.2	21.6	7.6
Amount utilized.....	.....	.....	294.5	199.3	590.3	45.8
Per cent utilized.....	.....	.....	91.1	94.2	96.5	85.8
Average food consumed per subject per day....	1,172.4	781.4	108.0	72.7	192.9	17.4

Summary of digestion experiments with Boston mackerel in a simple mixed diet.

Experiment No.	Subject.	Protein.	Fat.	Carbohy- drates.	Ash.
		<i>Per cent.</i>	<i>Per cent.</i>	<i>Per cent.</i>	<i>Per cent.</i>
444.....	D. G. G.....	94.7	95.9	95.1	90.1
446.....	R. L. S.....	92.4	96.2	96.6	83.8
447.....	O. E. S.....	91.1	94.2	96.5	85.8
	Average.....	92.7	95.4	96.1	86.6

An average of 108 grams of protein, 73 grams of fat, and 193 grams of carbohydrates was consumed per man daily during the test periods with Boston mackerel, the fuel value of the diet being 1,861 calories. These constituents were found to be 92.7 per cent, 95.4 per cent, and 96.1 per cent digested, respectively. The coefficients of digestibility for the fish protein and fat were found to be 93.1 per cent and 95.2 per cent, respectively, when allowance was made for the undigested protein and fat resulting from the basal ration.

BUTTERFISH.

Butterfish (*Poronotus triacanthus*) was chosen for one series of studies as an excellent fish of the type commonly used as pan fish. Butterfish occurs on the Atlantic and Gulf coasts from Maine to Texas, and during the year 1915 the catch of the coastal fisheries of New York and New Jersey amounted to over 5,000,000 pounds. At times it is taken in such abundance that a glut in the market results, and, since this fish is usually sold fresh, great quantities are wasted. The butterfish which was studied in the experiments here reported was of a good commercial grade, purchased in the local market, and it was believed to be representative of this type of fish procured under the ordinary trade conditions.

The three subjects who assisted in the study of the digestibility of butterfish, following the same routine which has hitherto proved entirely satisfactory, ate an average of 105 grams of protein, 37 grams of fat, and 208 grams of carbohydrates, daily, the fuel value of the diet being 1,585 calories. The data obtained for the three-day test period are included in the following table:

Data of digestion experiments with butterfish in a simple mixed diet.

Experiment, subject, and diet.	Weight of food.	Constituents of foods.				
		Water.	Protein.	Fat.	Carbohydrates.	Ash.
Experiment No. 452, subject D. G. G.:	<i>Grams.</i>	<i>Grams.</i>	<i>Grams.</i>	<i>Grams.</i>	<i>Grams.</i>	<i>Grams.</i>
Butterfish (in form of fish loaf).....	1,533.0	1,120.9	303.7	74.5	.....	33.9
Potato.....	115.0	86.8	2.9	0.1	24.0	1.2
Crackers.....	322.0	22.2	26.1	43.1	228.0	2.6
Fruit.....	1,259.0	1,065.1	5.0	6.3	178.8	3.8
Sugar.....	189.0	.....	.....	.....	189.0	.....
Total food consumed.....	3,418.0	2,295.0	337.7	124.0	619.8	41.5
Feces.....	46.0	.....	22.8	7.5	11.3	4.4
Amount utilized.....	.....	.....	314.9	116.5	608.5	37.1
Per cent utilized.....	.....	.....	93.2	94.0	98.2	89.4
Experiment No. 454, subject R. L. S.:						
Butterfish (in form of fish loaf).....	1,419.0	1,037.6	281.1	69.0	.....	31.3
Potato.....	139.0	104.9	3.5	0.1	29.1	1.4
Crackers.....	355.0	24.5	28.8	47.6	251.3	2.8
Fruit.....	1,423.0	1,203.8	5.7	7.1	202.1	4.3
Sugar.....	163.0	.....	.....	.....	163.0	.....
Total food consumed.....	3,499.0	2,370.8	319.1	123.8	645.5	39.8
Feces.....	60.0	.....	24.9	9.5	16.5	9.1
Amount utilized.....	.....	.....	294.2	114.3	629.0	30.7
Per cent utilized.....	.....	.....	92.2	92.3	97.4	77.1
Experiment No. 455, subject O. E. S.:						
Butterfish (in form of fish loaf).....	1,290.0	943.2	255.6	62.7	.....	28.5
Potato.....	569.0	429.6	14.2	0.6	118.9	5.7
Crackers.....	122.0	8.4	9.9	16.3	86.4	1.0
Fruit.....	1,474.0	1,247.0	5.9	7.4	209.3	4.4
Sugar.....	196.0	.....	.....	.....	196.0	.....
Total food consumed.....	3,651.0	2,688.2	285.6	87.0	610.6	39.6
Feces.....	68.0	.....	29.6	14.5	14.3	9.6
Amount utilized.....	.....	.....	256.0	72.5	596.3	30.0
Per cent utilized.....	.....	.....	89.6	83.3	97.7	75.8
Average food consumed per subject per day....	1,174.2	810.5	104.7	37.2	208.4	13.4

Summary of digestion experiments with butterfish in a simple mixed diet.

Experiment No.	Subject.	Protein.	Fat.	Carbohy- drates.	Ash.
		<i>Per cent.</i>	<i>Per cent.</i>	<i>Per cent.</i>	<i>Per cent.</i>
452.....	D. G. G.	93.2	94.0	98.2	89.4
454.....	R. L. S.	92.2	92.3	97.4	77.1
455.....	O. E. S.	89.6	83.3	97.7	75.8
	Average.....	91.7	89.9	97.8	80.8

In the digestion experiments made with butterfish, the subjects ate an average of 471 grams of fish daily, which supplied 93 grams of protein and 23 grams of fat. The protein, fat, and carbohydrates of the total diet were found to be 91.7 per cent, 89.9 per cent, and 97.8 per cent digested, respectively. The values 91.7 per cent and 89.9 per cent for the digestibility of the protein and fat of the total diet become 91.9 per cent and 86.4 per cent, respectively, if allowance is made for the undigested protein and fat resulting from the basal ration. The estimated value, 86.4 per cent, for the digestibility of the fat of butterfish is somewhat lower than that of the other fish fats here reported. This lower value is no doubt in part due to the "heaping up of errors" involved in estimating the digestibility of a fat of a single food when it represents so small a portion of the total fat eaten. The subjects reported that they remained in normal physical condition during the experimental periods, except that subjects D. G. G. and O. E. S. reported that the diet produced a constipating effect, which was due, no doubt, to its very complete utilization.

GRAYFISH.

The grayfish (*Squalus acanthias*, Linnæus), which is very abundant and easy to catch, though known to be wholesome, of good flavor, and usable for many appetizing dishes, has not been utilized to any extent in this country for food purposes, but has been considered largely as a source of oil and fish scrap, a fishery industry by-product of value for fertilizer material. Recently the Bureau of Fisheries has devoted considerable attention to the possible use of this fish in human nutrition and is of the opinion that it constitutes a cheap and very wholesome food.

In the literature consulted, no reports were found of the digestibility of grayfish. In order to judge of the value of the grayfish in the dietary, it seemed desirable to obtain information on this point, and, accordingly, tests were made in which canned grayfish was served in the form of a fish loaf in conjunction with the simple basal ration employed in the other tests reported in this paper. The canned fish used for this study was supplied by the Bureau of Fisheries and was taken to be representative of a large pack put up by a commercial concern under the direction of the Bureau of Fisheries.

Denis ¹ in a study of the blood of a number of fishes found urea in the blood of the grayfish. An analysis of the canned grayfish showed that the flesh of this fish contained both ammoniacal and urea nitrogen. The amount of nitrogen present in this form is, however, relatively small, and when allowance was made in the experiments which follow for this nonprotein nitrogen it was found that the value for the coefficient of digestibility of protein was not materially changed.

Eight digestion experiments have been made with the grayfish and the results obtained for the three-day test period are reported in the following table:

Data of digestion experiments with grayfish in a simple mixed diet.

Experiment, subject, and diet.	Weight of food.	Constituents of foods.				
		Water.	Protein.	Fat.	Carbohy- drates.	Ash.
Experiment No. 535, subject H. R. G.:	<i>Grams.</i>	<i>Grams.</i>	<i>Grams.</i>	<i>Grams.</i>	<i>Grams.</i>	<i>Grams.</i>
Grayfish (in form of fish loaf)	1,409.0	971.2	244.3	160.8	.....	32.7
Potato	486.0	366.9	12.1	0.5	101.6	4.9
Crackers	400.0	27.6	32.4	53.6	283.2	3.2
Fruit	581.0	491.5	2.3	2.9	82.5	1.8
Sugar .....	.....	.....	.....	.....	.....	.....
Total food consumed	2,876.0	1,857.2	291.1	217.8	467.3	42.6
Feces	64.0	.....	37.8	7.3	15.3	3.6
Amount utilized .....	.....	.....	253.3	210.5	452.0	39.0
Per cent utilized .....	.....	.....	87.0	96.6	96.7	91.5
Experiment No. 537, subject P. K.:	.....	.....	.....	.....	.....	.....
Grayfish (in form of fish loaf)	1,621.0	1,117.3	281.1	185.0	.....	37.6
Potato	507.0	382.8	12.7	0.5	105.9	5.1
Crackers	529.0	36.5	42.9	70.9	374.5	4.2
Fruit	890.0	752.9	3.6	4.4	126.4	2.7
Sugar .....	.....	.....	.....	.....	.....	.....
Total food consumed	3,547.0	2,289.5	340.3	260.8	606.8	49.6
Feces	39.0	.....	17.7	8.5	8.1	4.7
Amount utilized .....	.....	.....	322.6	252.3	598.7	44.9
Per cent utilized .....	.....	.....	94.8	96.7	98.7	90.5
Experiment No. 538, subject C. J. W.:	.....	.....	.....	.....	.....	.....
Grayfish (in form of fish loaf)	1,331.0	917.4	230.8	151.9	.....	30.9
Potato	452.0	341.3	11.3	0.4	94.5	4.5
Crackers	202.0	13.9	16.4	27.1	143.0	1.6
Fruit	944.0	798.6	3.8	4.7	134.1	2.8
Sugar	12.0	.....	.....	.....	12.0	.....
Total food consumed	2,941.0	2,071.2	262.3	184.1	383.6	39.8
Feces	65.0	.....	27.7	13.9	14.9	8.5
Amount utilized .....	.....	.....	234.6	170.2	368.7	31.3
Per cent utilized .....	.....	.....	89.4	92.4	96.1	78.6
Experiment No. 547, subject H. R. G.:	.....	.....	.....	.....	.....	.....
Grayfish (in form of fish loaf)	1,142.0	762.2	219.7	132.2	.....	27.9
Potato	425.0	320.9	10.6	0.4	88.8	4.3
Crackers	343.0	23.7	27.8	46.0	242.8	2.7
Fruit	599.0	506.8	2.4	3.0	85.0	1.8
Sugar .....	.....	.....	.....	.....	.....	.....
Total food consumed	2,509.0	1,613.6	260.5	181.6	416.6	36.7
Feces	49.0	.....	26.7	7.6	9.7	5.0
Amount utilized .....	.....	.....	233.8	174.0	406.9	31.7
Per cent utilized .....	.....	.....	89.8	95.8	97.7	86.4

¹ Jour. Biol. Chem., 16 (1913), No. 3, pp. 389-393.

Data of digestion experiments with grayfish in a simple mixed diet—Continued.

Experiment, subject, and diet	Weight of food.	Constituents of foods.				
		Water.	Protein.	Fat.	Carbohy- drates.	Ash.
Experiment No. 548, subject A. J. H.:	<i>Grams.</i>	<i>Grams.</i>	<i>Grams.</i>	<i>Grams.</i>	<i>Grams.</i>	<i>Grams.</i>
Grayfish (in form of fish loaf).....	1,097.0	732.1	211.1	127.0	.....	26.8
Potato.....	.....	.....	.....	.....	.....	.....
Crackers.....	76.0	5.2	6.2	10.2	53.8	0.6
Fruit.....	168.0	142.1	0.7	0.8	23.9	0.5
Sugar.....	4.0	.....	.....	.....	4.0	.....
Total food consumed.....	1,345.0	879.4	218.0	138.0	81.7	27.9
Feces.....	19.0	.....	6.5	5.7	3.7	3.1
Amount utilized.....	.....	.....	211.5	132.3	78.0	24.8
Per cent utilized.....	.....	.....	97.0	95.9	95.5	88.9
Experiment No. 549, subject P. K.:	.....	.....	.....	.....	.....	.....
Grayfish (in form of fish loaf).....	1,634.0	1,090.5	314.4	189.2	.....	39.9
Potato.....	500.0	377.5	12.5	0.5	104.5	5.0
Crackers.....	463.0	32.0	37.5	62.0	327.8	3.7
Fruit.....	926.0	783.4	3.7	4.6	131.5	2.8
Sugar.....	.....	.....	.....	.....	.....	.....
Total food consumed.....	3,523.0	2,283.4	368.1	256.3	563.8	51.4
Feces.....	36.0	.....	15.4	9.9	6.1	4.6
Amount utilized.....	.....	.....	352.7	246.4	557.7	46.8
Per cent utilized.....	.....	.....	95.8	96.1	98.9	91.1
Experiment No. 579, subject P. K.:	.....	.....	.....	.....	.....	.....
Grayfish (in form of fish loaf).....	1,175.0	773.7	230.5	153.0	.....	17.8
Potato.....	434.0	327.7	10.9	0.4	90.7	4.3
Crackers.....	416.0	28.7	33.7	55.8	294.5	3.3
Fruit.....	1,038.0	878.1	4.2	5.2	147.4	3.1
Sugar.....	35.0	.....	.....	.....	35.0	.....
Total food consumed.....	3,098.0	2,008.2	279.3	214.4	567.6	28.5
Feces.....	34.0	.....	13.6	10.0	5.9	4.5
Amount utilized.....	.....	.....	263.7	204.4	561.7	24.0
Per cent utilized.....	.....	.....	95.1	95.3	99.0	84.2
Experiment No. 580, subject C. J. W.:	.....	.....	.....	.....	.....	.....
Grayfish (in form of fish loaf).....	1,151.0	757.9	225.8	149.9	.....	17.4
Potato.....	462.0	348.8	11.5	0.5	96.6	4.6
Crackers.....	185.0	12.7	15.0	24.8	131.0	1.5
Fruit.....	1,168.0	988.1	4.7	5.8	165.9	3.5
Sugar.....	112.0	.....	.....	.....	112.0	.....
Total food consumed.....	3,078.0	2,107.5	257.0	181.0	505.5	27.0
Feces.....	58.0	.....	22.8	15.5	11.5	8.2
Amount utilized.....	.....	.....	234.2	165.5	494.0	18.8
Per cent utilized.....	.....	.....	91.1	91.4	97.7	69.6
Average food consumed per subject per day.....	954.9	629.6	94.9	68.1	149.7	12.6

Summary of digestion experiments with grayfish in a simple mixed diet.

Experiment No.	Subject.	Protein.	Fat.	Carbohy- drates.	Ash.
		<i>Per cent.</i>	<i>Per cent.</i>	<i>Per cent.</i>	<i>Per cent.</i>
535.....	H. R. G.....	87.0	96.6	96.7	91.5
537.....	P. K.....	94.8	96.7	98.7	90.5
538.....	C. J. W.....	89.4	92.4	96.1	78.6
547.....	H. R. G.....	89.8	95.8	97.7	86.4
548.....	A. J. H.....	97.0	95.9	95.5	88.9
549.....	P. K.....	95.8	96.1	98.9	91.1
579.....	P. K.....	95.1	95.3	99.0	84.2
580.....	C. J. W.....	91.1	91.4	97.7	69.6
	Average.....	92.5	95.0	97.5	85.1

Considering the diet as a whole, 95 grams of protein, 68 grams of fat, and 150 grams of carbohydrates were eaten per day, of which 92.5 per cent of the protein, 95 per cent of the fat, and 97.5 per cent of the carbohydrates were digested. The fuel value of the diet was 1,592 calories. The estimated digestibility of grayfish protein and fat as obtained by making allowance for the unutilized protein and fat resulting from the accessory foods of the diet are 92.8 per cent and 94.3 per cent, respectively.

The four different subjects who assisted in the eight experiments conducted to determine the digestibility of grayfish ate on an average 440 grams of grayfish daily as compared with 471 grams of butterfish, 448 grams of mackerel, and 355 grams of salmon, which would indicate that this fish was eaten with as much relish as the other fish studied.

SALMON.

Since difficulty was experienced in securing fresh salmon for the purpose of this investigation, a good grade of canned salmon (Chinook salmon, *Oncorhynchus tshawytscha*) was used instead in the experiments here reported. The canned salmon was purchased without regard to any commercial brand from a wholesale grocer, and was taken to represent this type of fish in general use.

The results obtained in three-day test periods with salmon are given in the table which follows:

Data of digestion experiments with salmon in a simple mixed diet.

Experiment, subject, and diet	Weight of food.	Constituents of foods.				
		Water.	Protein.	Fat.	Carbohydrates.	Ash.
Experiment No. 561, subject H. R. G.:	<i>Grams.</i>	<i>Grams.</i>	<i>Grams.</i>	<i>Grams.</i>	<i>Grams.</i>	<i>Grams.</i>
Salmon (in form of fish loaf).....	1,004.0	621.8	249.8	108.8	.....	23.6
Potato.....	411.0	310.3	10.3	0.4	85.9	4.1
Crackers.....	297.0	20.5	24.0	39.8	210.3	2.4
Fruit.....	514.0	434.8	2.1	2.6	73.0	1.5
Sugar.....	23.0	.....	.....	.....	23.0	.....
Total food consumed.....	2,249.0	1,387.4	286.2	151.6	392.2	31.6
Feces.....	46.0	.....	23.3	4.7	13.5	4.5
Amount utilized.....	.....	.....	262.9	146.9	378.7	27.1
Per cent utilized.....	.....	.....	91.9	96.9	96.6	85.8
Experiment No. 562, subject A. J. H.:						
Salmon (in form of fish loaf).....	854.0	528.9	212.5	92.5	.....	20.1
Potato.....	.....	7.2	8.4	14.0	73.6	0.8
Crackers.....	104.0	87.2	0.4	0.5	14.6	0.3
Fruit.....	103.0	.....	.....	.....	24.0	.....
Sugar.....	24.0	.....	.....	.....	.....	.....
Total food consumed.....	1,085.0	623.3	221.3	107.0	112.2	21.2
Feces.....	42.0	.....	18.3	12.1	6.7	4.9
Amount utilized.....	.....	.....	203.0	94.9	105.5	16.3
Per cent utilized.....	.....	.....	91.7	88.7	94.0	76.9

Data of digestion experiments with salmon in a simple mixed diet—Continued.

Experiment, subject, and diet.	Weight of food.	Constituents of foods.				
		Water.	Protein.	Fat.	Carbohy- drates.	Ash.
Experiment No. 563, subject P. K.:	<i>Grams.</i>	<i>Grams.</i>	<i>Grams.</i>	<i>Grams.</i>	<i>Grams.</i>	<i>Grams.</i>
Salmon (in form of fish loaf).....	1,286.0	796.4	320.0	139.4	.....	30.2
Potato.....	553.0	417.5	13.8	0.6	115.6	5.5
Crackers.....	325.0	22.4	26.3	43.6	230.1	2.6
Fruit.....	717.0	606.6	2.9	3.6	101.8	2.1
Sugar.....	60.0	.....	.....	.....	60.0	.....
Total food consumed.....	2,941.0	1,842.9	363.0	187.2	507.5	40.4
Feces.....	49.0	.....	16.4	6.2	19.1	7.3
Amount utilized.....	.....	.....	346.6	181.0	488.4	33.1
Per cent utilized.....	.....	.....	95.5	96.7	96.2	81.9
Experiment No. 564, subject C. J. W.:						
Salmon (in form of fish loaf).....	1,115.0	690.5	277.4	120.9	.....	26.2
Potato.....	431.0	325.4	10.8	0.4	90.1	4.3
Crackers.....	177.0	12.2	14.4	23.7	125.3	1.4
Fruit.....	842.0	712.3	3.4	4.2	119.6	2.5
Sugar.....	105.0	.....	.....	.....	105.0	.....
Total food consumed.....	2,670.0	1,740.4	306.0	149.2	440.0	34.4
Feces.....	56.0	.....	23.6	7.4	18.4	6.6
Amount utilized.....	.....	.....	282.4	141.8	421.6	27.8
Per cent utilized.....	.....	.....	92.3	95.0	95.8	80.8
Average food consumed per subject per day....	745.4	466.2	98.0	49.6	121.0	10.6

Summary of digestion experiments with salmon in a simple mixed diet.

Experiment No.	Subject.	Protein.	Fat.	Carbo- hydrates.	Ash.
		<i>Per cent.</i>	<i>Per cent.</i>	<i>Per cent.</i>	<i>Per cent.</i>
561.....	H. R. G.....	91.9	96.9	96.6	85.8
562.....	A. J. H.....	91.7	88.7	94.0	76.9
563.....	P. K.....	95.5	96.7	96.2	81.9
564.....	C. J. W.....	92.3	95.0	95.8	80.8
	Average.....	92.9	94.3	95.7	81.4

In the test periods in which canned salmon was included in the experimental ration, the subjects ate an average of 355 grams of salmon daily. The total diet eaten supplied 98 grams of protein, 50 grams of fat, and 121 grams of carbohydrates per day, and the coefficients of digestibility were found to be 92.9 per cent for protein, 94.3 per cent for fat, and 95.7 per cent for carbohydrates. The fuel value of the diet was 1,326 calories. When allowance is made for the undigested protein and fat residues occurring in the feces resulting from the accessory foods of the diet, the digestibility for the protein and fat of salmon is found to be 93.2 per cent and 93.7 per cent, respectively, and indicates that salmon is very completely utilized by the human body.

SUMMARY.

In the study of the digestibility of the protein and fat supplied by some common varieties, fish in the form of "fish loaf" was served as the major part of a simple mixed diet, which also included potatoes, crackers, fruit, sugar, and tea or coffee. The principal results are summarized in the following table:

Summary of results of all digestion experiments.

Number of experiments.	Kind of fish.	Average amount of fish eaten per man per day.	Digestibility of fish protein.	Digestibility of fish fat.
		Grams.	Per cent.	Per cent.
3.....	Mackerel.....	448	93.1	95.2
3.....	Butterfish.....	471	91.9	86.4
8.....	Grayfish.....	440	92.8	94.3
4.....	Salmon.....	355	93.2	93.7

On an average, the subjects ate 448 grams of Boston mackerel, 471 grams of butterfish, 440 grams of grayfish, and 355 grams of salmon daily, which would indicate that in every case the fish was eaten with relish.

Considering the experiments as a whole, the total diet supplied on an average 99 grams of protein, 60 grams of fat, and 160 grams of carbohydrates daily, the fuel value being 1,576 calories. The low amount of fat and of carbohydrates was due to the fact that butter and similar fat were omitted and the foods other than fish loaf which supplied both protein and carbohydrates, were limited in order that both the fat and the protein in the diet might be contributed in as large proportion as possible by the fish.

The average coefficients of digestibility for fish proteins were: Boston mackerel, 93.1 per cent; butterfish, 91.9 per cent; grayfish, 92.8 per cent; and salmon, 93.2 per cent. In view of the close agreement, it would seem, from a dietetic standpoint, that the different fishes studied would supply protein in equally available form.

The average coefficients of digestibility of the fish fats were found to be as follows: Boston mackerel, 95.2 per cent; butterfish, 86.4 per cent; grayfish, 94.3 per cent; and salmon, 93.7 per cent. As these figures show, the fats were well assimilated in the case of the mackerel, grayfish, and salmon, which, according to the usual custom, are to be regarded as "fat fishes." Considering the experiments as a whole, the very complete utilization of the protein and fat supplied by the fishes studied offer additional experimental evidence that fish is a very valuable food and that its extensive use in the dietary is especially desirable.

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Contribution from the Office of Farm Management
W. J. SPILLMAN, Chief

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LEASE CONTRACTS USED IN
RENTING FARMS ON SHARES

A STUDY OF THE DISTRIBUTION OF INVESTMENTS, EXPENSES
AND INCOMES BETWEEN LANDLORD AND TENANT

By

E. V. WILCOX, Agriculturist

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LEASE CONTRACTS USED IN RENTING FARMS
ON SHARES.[A study of the distribution of investments, expenses, and income between
landlord and tenant.]By E. V. WILCOX, *Agriculturist.*

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DIFFERENT SYSTEMS.

About 37 per cent of the farms in the United States are operated by tenants under lease. Acute interest is being manifested by both landowners and tenants in the general features and special stipulations of lease contracts. Numerous inquiries are being made as to proper methods of sharing equipment, labor, and other expenses involved in farm operations, and as to the proper fractions to use in dividing proceeds. Practically all these questions are of an agricultural rather than a legal nature. It is a matter of much importance, therefore, to study lease contracts from a pure farm management standpoint. The wording of a lease is a comparatively simple problem after the conditions essential to fairness have been agreed upon. Several methods of leasing are in use, as shown by an examination of leases in force. Farms may be rented for cash, either a stipulated

sum for the whole farm or a certain cash rent per acre. Cash rent varies according to local conditions from \$2 to \$30 per acre, being commonly \$4 to \$10 per acre in the north central States. Under the cash renting system the landlord furnishes simply the real estate while the tenant furnishes all working capital, bears all operating expenses, and receives all proceeds. A modified form of this system consists in paying a specified number of bushels of grain or bales of cotton, etc., in lieu of cash.

A great many methods of share leasing are to be noted. Under this system much variation exists in the methods of sharing equipment and expenses, the proceeds being divided accordingly half-and-half, one-third and two-thirds, one-fourth and three-fourths, two-fifths and three-fifths, two-sevenths and five-sevenths, or by some other fraction. For example, "share croppers" on cotton farms furnish nothing but labor and receive one-half of the cotton. "Share renters" furnish labor, tools, and mules and receive two-thirds of the cotton on very fertile land or three-fourths on poorer land. On some share-rented general farms the tenant may supply all live stock and receive a share of the crops and all animal products, or productive stock may be jointly owned and the products shared.

In many cases the chief crop areas of the farm are rented on shares, while the tenant pays cash for the farmstead, pasture, hay land, corn land, or some other specified area. This method of leasing is commonly called the share-cash system.

Lease forms.—Printed lease forms seem to be of little avail except on large estates where the whole system has been thoroughly worked out by the manager, and where a uniform set of conditions is prescribed for all tenants on the estate. For the most part, however, printed lease forms contain only generalities. Usually it is necessary for landlord and tenant to agree by consultation on the features of the contract and then write a lease embodying these stipulations. Very often no written contract is made, the agreement being merely verbal. A written lease is more satisfactory, however, especially in the event of some subsequent disagreement or misunderstanding.

Basis of discussion.—The following discussion of the various features of leases is based partly on a study of lease contracts in actual operation and partly on surveys of tenant farms throughout the country. These leases and survey records not only show the great variation in lease contracts under different conditions, but also indicate a basis for a rational lease form providing a reasonably just and fair sharing of equipment, expenses, and proceeds. The number of lease contracts examined was 258, every State being represented. The number of tenant farm survey records studied with regard to

the essential features of the lease agreement was 2,907, including records from 414 dairy farms, 320 stock farms, 298 general farms in the corn belt, 1,113 cotton farms, 453 wheat farms, 176 potato farms, 100 sugar-beet farms, and 33 bean farms. The lease contract often contains minor specific agreements between landowner and tenant not definitely indicated in a farm survey record. All available farm leases, therefore, have been examined with reference to those points.

LENGTH OF LEASE PERIOD.

In a majority of cases the lease runs for only one year, usually with privilege of renewal upon one or two months' notice. Often the lease provides more positively that the contract is understood to be continuous from year to year unless due notice of intent to discontinue is served by either party. The lease year may coincide with the calendar year, or, more commonly, with the crop year (March 1 to March 1).

Contrary to natural expectation and popular belief, annual lease contracts may not mean more frequent moving of the tenant than do long-term contracts. In fact, investigations on Wisconsin and Illinois dairy farms show that tenants remain longer on the same farm under an annual renewable lease than under lease contracts of two, three, or five years' duration. On Kansas grain farms tenants often have remained 15 to 20 years on the same farm under an annual lease. Moreover, in some sections tenants have operated the same farm 25 to 50 years under annual leases, in the meantime buying farms which they in turn have leased to others. In fact, there are leaseholds which have descended from father to son, the present tenants having been born on farms then operated by their fathers, thus continuing tenant occupancy under annual lease without change into the second generation. Formerly farms might be leased in New York for as long as 99 years, but in 1846 the New York Legislature passed a law prohibiting leasing under longer contracts than 12 years. The purpose of this law was to check the establishment of a tenant class.

England is often incorrectly cited as a country where tenancy problems have been solved by the adoption of a system of long-term leases. As a matter of fact, the vast majority of leases in England are for one year only, and are renewable. The same tendency is seen in the United States.

Most lease contracts with negro tenants on cotton farms, Polish tenants on onion farms, Italian tenants on strawberry farms, Portuguese tenants on bean farms, and Japanese and Chinese tenants on potato farms are verbal, annual, and renewable. In general, the

duration and permanency of tenant tenure seem not to be correlated with either a written or a verbal form of lease.¹

Many tenants and some landowners prefer long-term leases, running 5 to 10 years. Replies to a questionnaire recently addressed to tenants on Kansas wheat farms show that in almost every case the tenant would prefer a contract longer than one year. In a survey of 143 tenant dairy farms in Wisconsin and Illinois 76 per cent of the leases in Wisconsin and 66 per cent of those in Illinois were for one year, while 14 per cent of those in Illinois were for five years.

In the case of certain special conditions a long-term lease is required for the successful fulfillment of the contract. When live stock is leased it is customary to make a contract for 5 to 10 years. Contracts with a tenant for clearing land commonly give the tenant 5 or 6 years to bring the land into condition and receive adequate returns for the labor of clearing. On an Indiana farm rented for growing nursery stock the lease ran 8 years to enable all nursery stock to mature and to allow time for selling the matured stock to compensate for the extra preparatory expense of the first 2 years. Moreover, in various States an occasional farm devoted to general farming is leased for 10 years or more, rarely under a 15-year contract.

METHODS OF SHARING CROPS AND STOCK PRODUCTS.

FIELD CROPS.

Corn.—On general farms in the corn belt when the tenant furnishes working capital and hired labor the landowner commonly receives one-half of the corn as well as of other crops. This is the prevailing custom in Indiana, Illinois, Iowa, Kansas, Missouri, Nebraska, North Dakota, South Dakota, Ohio, Pennsylvania, Maryland, Tennessee, Virginia, West Virginia, Wisconsin, and Minnesota. Considerable variation in the share of corn, however, is to be noted in these States. Sometimes the landlord receives only two-fifths, one-third, or even one-fourth of the corn. On certain New Jersey

¹ The legal requirements governing the execution and recording of leases are usually prescribed by statute. It might be stated as a general rule of law that "All that is necessary to the execution of a lease is that it should be signed and delivered. It is not necessary that it should be witnessed or acknowledged except for the purpose of entitling it to record." (L. A. Jones, A Treatise on the Law of Landlord and Tenant.) This general rule is modified, however, in one or more particulars by the statutory law of many of the States. For example, most States require that leases for three years or longer be executed with the usual formality of a deed, while in one State at least no lease of land, except it be by deed, is effectual for more than one year. (Revised Code of Delaware, 1915.) "In practically every jurisdiction, by statutory enactment, every lease of land, or interest therein, for a period in excess of that designated by statute, must be recorded in the county where the land is situated, and a failure to so record will render the lease void as to subsequent encumbrancers and purchasers without notice, and for a valuable consideration, who first duly record their conveyances." (Encyclopedia of Law and Procedure.)

farms where the landowner pays all expenses, including hired labor, he receives two-thirds of the corn. The same fraction for division of the corn is used on Ohio farms where the tenant receives a small guaranteed wage in addition to one-third of the corn. Occasionally in Virginia the tenant supplies three-fourths of the fertilizer on corn land and receives three-fourths of the corn. Share croppers on cotton farms, who furnish nothing but labor, commonly receive one-half of the corn or pay cash rent for corn land, while share renters, who furnish the working capital and the labor, usually get two-thirds of the corn. In cases on Colorado farms where the tenant supplies tools and horses and pays all expenses the landowner receives one-third of the corn. On general farms in Delaware the landowner usually gets one-half of all crops, including corn.

Wheat and other grain and seed crops.—The examination of 453 survey records¹ on tenant wheat farms in Kansas, Nebraska, Minnesota, North Dakota, and Montana shows that on 267 of these farms the landowner receives one-third, on 106 farms one-half, and on 80 farms two-fifths of the wheat. On these farms the tenant supplied working capital and hired labor. Occasionally other fractions, such as two-sevenths or five-twelfths are used in dividing the wheat in the wheat States of the upper Mississippi valley. Through the corn belt the tenant usually pays one-half of the wheat and other grains on share-rented farms. Very generally where several cereal grains are raised on the same farm all of these grains are divided between landlord and tenant by the same fraction, the lease prescribing that the landowner shall receive either one-half or one-third of all grain. The landowner's share of small cereal grains, as is the case with many other crops, is smaller in western States than in the corn belt. Frequently the landowner receives only one-third of the wheat and other grain, especially when the tenant pays thrashing expenses, as compared with one-half of the corn. Rye is commonly divided half and half. In the cotton belt share croppers usually receive one-half of the oats and share renters two-thirds. In Colorado the landowner commonly receives one-third of the oats and less often one-half, while in the corn belt and various other States the landowner usually receives one-half of the oats or more rarely one-third or two-fifths. On some New Jersey farms the landlord may pay all expenses and receive two-thirds of the oats and wheat, his share otherwise being one-half.

On rice farms in Texas when the tenant supplies tools and mules and the landlord furnishes all seed and water, the landlord commonly receives either two-fifths or one-half of the rice, depending upon the location and fertility of the farm.

¹ Records furnished for examination by courtesy of Office of Extension Work in the North and West, States Relations Service.

Millet is seldom a crop of sufficient importance on tenant farms to be mentioned in a lease contract. On a half share rented farm in Texas the landowner receives one-half of the millet.

The division of clover and alfalfa seed on tenant farms is rarely specified in lease contracts, and few records are therefore available in reference to this point. In Indiana the landowner commonly receives two-fifths of the clover seed produced on the farm. In Colorado the landowner may receive one-half of the alfalfa seed produced on the farm as compared with one-third of the corn and potatoes grown on the same farm.

Sunflowers are rarely an important enterprise on tenant farms. On one Kentucky farm where this crop is grown on a considerable scale the expense and equipment are shared equally and the landlord receives one-half of the sunflower seed, as well as one-half of the corn and alfalfa. In this case the work stock is fed from undivided feed.

Hay and fodder.—Almost universally on share rented farms, when the tenant furnishes working capital and hired labor, hay is divided half-and-half if sold at all. Otherwise the hay produced on the farm is used in feeding partnership stock, but if the landowner owns no stock the tenant may pay cash rent for hay land.

On dairy farms and stock farms throughout the country it is frequently prescribed in the lease contract that hay and fodder shall not be sold except with the permission of the landlord, but shall be fed to the stock on the farm. On grain farms the tenant often pays a cash rent for hay land and has all the product to sell or to feed to his own stock. In general, when the hay is shared half-and-half the tenant is required to pay one-half of all expenses and to supply the necessary tools and work stock. In a few cases, however, the tenant receives three-fourths of the hay. In Alabama and elsewhere in the cotton belt share croppers on cotton farms commonly receive one-half of the corn fodder, sorghum, and other fodder produced on the farm. In Colorado when the tenant furnishes tools, horses, feed, labor, and thrashing expense, he usually receives one-half of the alfalfa and less often one-third. The baling expenses are usually shared proportionately to the share of the crop received by the tenant and landlord. On such farms the water assessment is commonly paid by the landlord, less often by the tenant, or sometimes is shared equally. In Kentucky, with all working capital and expense shared equally, the tenant's share of the alfalfa is one-half, while he may receive one-third of the timothy or less often three-fifths. Wide variation occurs on Nebraska farms with reference to the fractional sharing of hay, the tenant receiving one-half or three-fifths or even two-thirds as his share.

It is frequently stipulated in the lease that straw shall not be burned or removed from the farm. In some cases, however, it is specified that the land owner shall receive one-half or three-fourths of the straw.

In the few instances in which the division of sweet clover is mentioned in the lease contract this crop is divided for the most part half-and-half.

Cotton.—As already indicated, cotton is commonly raised on tenant farms under one or the other of two systems known as share cropping and share renting, cash renting being a less common method. Under the share cropping system the cotton crop is divided half and half. Some variations are noted in the customs which prevail in different States in regard to the share croppers. In Alabama the landlord commonly furnishes all machinery and work stock and one-half of the fertilizer; less frequently he furnishes all of the work stock and fertilizer, while the tenant furnishes all machinery and feed. The landlord commonly provides all seed and pays for one-half of the ginning. In Georgia the landlord usually provides all working capital and pays all expenses except for ginning and fertilizer, which are shared equally. The same arrangement prevails in Louisiana, but the tenant may also get one-half of the corn or pay cash rent for corn land, as is frequently the case in other cotton States. In Mississippi the tenant ordinarily supplies all labor and one-half the fertilizer, while the landlord provides cabin, garden, tools, mules, feed, seed, and fuel. The tenant may also pay cash rent for all land not planted in cotton. Occasionally in North Carolina the landlord furnishes all of the fertilizer. The landlord may furnish one-half or all of the fertilizer and one-half of the seed. Similar arrangements are customary in South Carolina, Oklahoma, Arkansas, and Texas. Share croppers are essentially laborers under a system which gives them a personal interest in securing good yields.

Under the method of share renting the tenant commonly furnishes mules, feed, tools, seed, and labor, while the landlord supplies land, cabin, garden, and fuel. For the most part the expenses for fertilizer, ginning, and bagging are paid by each party in proportion to his share of the crop. The landlord receives one-fourth or one-third of the cotton, according to local conditions and fertility of the soil. The understood conditions for share renting are practically the same in all of the cotton States. A law was passed in Texas prescribing that the landlord shall not receive more than one-third of the grain and one-fourth of the cotton for land leased under these conditions.

Under the cash renting system the tenant pays all expenses and the rent is paid in a specified number of bales of cotton. In Alabama

the tenant pays $1\frac{1}{2}$ to $2\frac{1}{2}$ bales of cotton per mule, but in Alabama and other cotton States the rent may be 2 to 3 bales per mule on more fertile land. Comparatively few tenants on cotton farms pay a fixed amount of money rent.

Potatoes.—Records on 176 New Jersey tenant farms on which potatoes are an important crop indicate that the potatoes were shared half-and-half on 157 farms on which the tenant furnished work stock, machinery, and hired labor, and by some other fraction on 19 farms. In New York, Pennsylvania, Maryland, and throughout the corn belt potatoes are commonly shared half-and-half. In the wheat States the landowner more commonly receives one-third of the potatoes. In the Greeley potato district of Colorado the common practice is for the landlord to receive one-third of the potatoes. In Delaware, when the landlord furnishes tools, machinery, work stock, and one-half of the potato seed, other expenses being shared equally, the crop is divided half-and-half. In a few instances in Indiana the landlord accepts as his share one-half of the potatoes in the field before digging, or one-third "in the bushel" (dug and measured), at the option of the tenant. Frequently, however, the potato crop is shared half-and-half "in the bushel." A common custom in North Dakota and elsewhere is for the landlord to furnish one-half of the seed potatoes, receiving one-half of the crop.

Sugar beets.—In Michigan, sugar beets are grown extensively by farmers who receive instructions from field superintendents employed by the sugar companies. The required contract labor is commonly secured through the factory manager and is paid for by the farmer. The farmers who grow sugar beets under these conditions do the work of blocking, thinning, hoeing, and topping. According to records obtained on 100 tenant farms in Colorado on which sugar beets are grown, the tenant invariably supplies all tools, feed, work stock, and labor, while the landlord pays the water assessments and land tax. Under this system the landlord receives one-fourth of the sugar beets. In a few instances, however, the landowner supplies tools, feed, supplies, horse labor, and twine, while the tenant provides all hand labor. Under this arrangement the landowner receives two-thirds of the sugar beets and all of the beet tops. Occasionally the landowner receives only one-fifth or one-sixth of the sugar beets. The prevailing fraction is one-fourth, and the present tendency is toward an even larger share. Moreover, in a few instances the tenant pays one-half of the water assessment. In practically all cases the tenant hauls the crop to market. Leases on sugar-beet farms are for the most part written and of one-year duration.

Tobacco.—The number of leases on tobacco farms available for study is not sufficient to determine with any certainty the most com-

mon method of sharing this crop, but a considerable variation is noted in the conditions mentioned in leases, particularly in Kentucky, Ohio,¹ Tennessee, and Virginia. On a number of Kentucky farms where the tenant furnishes all tools, work stock, and general seed, he receives two-thirds of the tobacco. Under this arrangement the expenses for fertilizer and fuel are usually shared proportionally to the division of the crop. In some instances, however, the landlord may bear one-half of the cost of baling the tobacco and receive one-half of the crop. On general farms in Ohio where tobacco is an important enterprise the tenant may furnish tools and work horses and receive four-sevenths of the tobacco, or the landowner may supply one-half of the seed and receive two-fifths of the tobacco. On certain Tennessee tobacco farms where the landlord provides all tools, mules, feed, and one-half of the fertilizer and spraying material, the tobacco is divided half-and-half. The same condition prevails in Virginia. When, on the other hand, the tenant supplies all tools, mules, feed, and seed, and pays for three-fourths of the fertilizer, he receives also three-fourths of the tobacco.

Flax.—Flax is frequently an important crop on tenant farms in North Dakota. On such farms the tenant commonly supplies the horses and tools, while the landowner provides all seed. Other expenses, including plowing, are commonly shared equally. Under these conditions the landlord receives one-half of the flax.

Hops.—In farm leases in New York in which the division of hops is mentioned, the tenant is usually required to furnish the tools and horses, while the landlord supplies all poles required for the growth of the crop. Other expenses, including sulphur, and labor for picking the hops, are shared equally and the crop is divided half-and-half.

ORCHARD FRUITS.

Fruit in general.—On farms on which fruit is not an important enterprise the lease contract often specifies a certain division of the fruit as a whole without mention of the kind of fruit. In some cases the landlord pays a horticulturist to teach the tenant how to prune and spray. The cost of spraying materials is usually shared in proportion to the division of the crop. Almost universally, under these conditions, the fruit is divided equally.

Nursery stock.—An Indiana farm was leased under a partnership arrangement for growing all kinds of nursery stock, including apple, peach, plum, pear, cherry, raspberry, blackberry, shrubbery, etc. The period of the lease was eight years. Under this arrangement the landlord received one-half of the wholesale price of all nursery

¹ In a group of 28 Ohio farms the landlord's share of the tobacco is two-fifths on 16 and one-half on 12 farms.

stock, and if any retail sales were made the tenant received the difference between the retail price and one-half of the wholesale price, as recompense for his extra labor in making small sales. Under this contract the landlord also received one-half of the fruit. The tenant supplied all equipment and paid all expenses, including marketing. At the expiration of the lease the remaining nursery stock was divided half-and-half.

Apples.—The apple crop is usually shared half-and-half between tenant and landlord. This is the prevailing custom in New York, Pennsylvania, Maryland, Indiana, Iowa, Nebraska, Colorado, and elsewhere. On New York farms when the tenant provides only the labor, the landlord receives two-thirds of the apples, while when all expenses, including apple storage and hired labor, are shared equally the crop is divided half-and-half. In Pennsylvania the landlord frequently pays two-thirds of the fertilizer bill for orchard crops on farms where the apples are shared half-and-half.

Peaches, pears, plums, and cherries.—The method of dividing these crops is mentioned so rarely in lease contracts that no reliable conclusion as to the usual practice can be drawn. From the small available number of lease records, however, it appears that on farms where all expenses are shared equally the crop of peaches, plums, and pears, is divided half-and-half. On New York farms, where the tenant sometimes supplies nothing but labor, the landlord may receive two-fifths of the cherries and two-thirds of the apples and peaches. On Indiana farms, when the tenant supplies horses and tools, and the cost of hired labor, marketing, and spraying is shared equally, the landlord receives one-half of the peaches. When the tenant furnishes only the labor on New York farms the landlord may receive two-thirds of the peaches, and when the tenant provides two-thirds of the barrels and all labor, while the landlord provides all fertilizer, spraying material, and horses, the landlord's share is one-third of the peaches and pears.

TRUCK CROPS AND BERRIES.

Onions.—On tenant farms in New Jersey devoted to truck raising, the landowner usually pays the taxes and fertilizer bills, while other expenses except labor are shared equally. The tenant supplies tools, machinery, and horses. On such farms the landowner receives one-half of the onions, but when the tenant supplies only labor the landowner's share is two-thirds.

On rented onion farms in Massachusetts the tenant usually provides hand tools, hand labor, and seed, while the landowner furnishes all horse labor and fertilizer and pays the taxes. The cost of bags is for the most part shared equally, but in some cases is paid by

the purchasers. Under these conditions the landowner receives one-half of the onions.

On rented onion farms in New York the tenant furnishes one-half the tools, fertilizer, and seed, and all hand labor, while the landowner supplies all horse labor and crates, and receives one-half of the onions.

Cabbage.—On New York cabbage farms where the tenant provides the tools, horses, and all labor, while other expenses are shared equally, the crop is divided half-and-half. On rented farms in Colorado where cabbage is an important enterprise, the tenant may furnish all tools, feed, supplies, and horse labor, and receive one-half the crop, or the landowner may furnish all tools, feed, supplies, and horse labor, while the tenant provides all hand labor and 45 per cent of the seed. Under the latter condition the tenant's share of the crop is 45 per cent.

Celery.—Certain small tenant farms in California are devoted almost exclusively to the production of celery. On such farms the landlord furnishes the tools, work stock, and feed, while the tenant provides all hand labor, including the labor of spraying. Under these conditions the landlord's share of the crop is two-thirds. The tenant on these farms, as is also the case on onion farms in Massachusetts, is really a laborer paid with a portion of the crop instead of a cash wage. Such leases are almost always verbal and run for only one year, but are renewable.

Cucumbers.—Few records are available showing the method of sharing this crop. Cucumbers are grown on a commercial scale under a system of tenancy on several farms in Colorado. The landowner commonly provides all tools, feed, supplies, horse labor, and seed, while the tenant furnishes all hand labor, and receives 70 per cent of the crop.

Tomatoes.—On certain tenant farms in Delaware where all expenses are shared equally except labor, which is furnished by the tenant, the landlord receives two-fifths of the tomatoes and one-half of the grain, but sometimes his share of the tomatoes is only one-fourth. In Maryland in cases where the tenant supplies tools, horses, and all labor, and where all other expenses, including seed, baskets, and crates, are shared equally, the landlord receives one-half the tomatoes. The common custom in New Jersey is for the landlord and tenant to furnish hampers and spraying material jointly, while the landlord pays the taxes and fertilizer bills and receives one-half the tomatoes. Occasionally the tenant furnishes only the labor, in which case the landlord's share of the tomatoes is two-thirds.

Cantaloupes.—A few of the tenant farms in Maryland produce cantaloupes on a large scale. On these farms the tenant supplies

the tools, mules, and labor, while other expenses are shared equally and the crop is divided half-and-half.

Peas and beans.—On 26 out of 33 tenant farms in Colorado on which beans are an important crop the landowner receives one-third of the beans as his share. Peas raised for canning purposes in Maryland are shared half-and-half when the tenant furnishes tools, work horses, and labor, other expenses being shared equally. In New York when the tenant supplies tools and horses, and all expenses are shared equally, the landlord receives one-half of the beans. In a few instances when dry navy beans are marketed the landlord receives one-half of the product, although he bears only 45 per cent of the expenses.

Berries and grapes.—In Maryland when the tenant furnishes tools and horses and the landlord pays all fertilizer bills the strawberries are divided half-and-half, under a lease stipulating that other expenses, including crates and picking labor, are to be shared equally. On strawberry farms in Louisiana when all expenses, including picking labor, are shared equally the crop is divided half-and-half. The tenant is required to take plants from old strawberry beds for replanting.

On berry farms in Kansas when the tenant furnishes tools and horses and the landowner all seed and plants, the rent paid by the tenant is one-half of the strawberries, raspberries, and grapes. On such farms the tenant is required to renovate old berry patches by plowing them up and planting them in cowpeas for one season.

LIVE STOCK AND STOCK PRODUCTS.

Cows.—In Arizona a system has grown up whereby cows are rented to farmers. Similar arrangements are noted occasionally elsewhere. A creamery owner may furnish cows to farmers for a portion of the cream returns each month or for a cash payment of 50 cents to \$1.50 per month. Under this system the owner of the cows also receives one-half of the increase in calves. Occasionally other owners of cows may rent them to farmers for one-half the increase, the calves to be divided when six months old and the farmer to have all of the milk.

Breeding dairy cattle.—In Wisconsin a business man may buy a herd of dairy cattle, including bull, cows, and heifers, and may then make a long-term contract, usually for five years, with a farm owner who is to take care of the herd on his farm. The farmer furnishes feed, care, stable room, veterinary fees, and all general running expenses. The owner of the herd pays insurance and taxes on the stock. Under this system bull calves are sold as is found convenient and the proceeds are divided half and half. The returns from the

sale of heifer calves previously to final settlement go two-thirds to the owner and one-third to the farmer. At the termination of the contract enough stock is sold to repay the owner for his original investment, while the remainder goes two-thirds to the owner and one-third to the farmer. In cases of this sort the farmer receives all of the milk.

According to another scheme somewhat in vogue in Wisconsin, the farmer stables, pastures, feeds, and cares for the cattle furnished by the breeder, and receives 50 cents a head per month from May to October, inclusive, and \$2 per head per month from November to April, inclusive. The farmer also receives \$1 per month per head for testing the cows to determine the milk yield and percentage of fat. The farmer and the cattle breeder share equally in the investment and in all expenses except feed and labor, which are furnished by the farmer. Moreover, the cattle breeder pays for stenographer, and other expenses connected with correspondence. Both share equally in the sales, but the farmer receives all of the milk.

These systems of handling cows and breeding stock are, of course, not comparable with any general system of leasing land for the purpose of stock production, since the farm owner is virtually a tenant in relation to the cattle breeder or owner of the live stock. The few cases in which the conditions of the contract arrangement are known are merely considered interesting as showing the methods which have been adopted for handling such problems.

Milk and cream.—On dairy farms in all States where expenses are shared equally the landowner receives one-half the milk, whether it is sold as market milk or to a condenser, butter factory, or cheese factory, or one-half of the cream. The landlord may furnish one-half the cows and sometimes one-half the tools and work horses. In some States the landlord furnishes all of the cows, but the tenant must bear half of the expense of cows purchased to keep up the herd and replace cows that die. Sometimes, as in Sussex County, N. J., the tenant furnishes only labor and one-third of the feed and fertilizer, receiving one-third of the milk proceeds. A similar arrangement is found in Delaware.

Beef cattle.—In several States where the production of beef cattle has become a large industry, as in Iowa, for example, the tenant may furnish tools and work horses, haul the milk and pay the road taxes, while the landlord pays other real estate taxes and furnishes one-half the cows, beef cattle, and hogs. In cases of this sort the cost of feed and seed is shared equally and the proceeds from the cattle which are sold are divided half and half.

A breeder of Angus cattle in Illinois rented herds of these cattle to a number of farmers for 10 years. The bull calves were sold as

opportunities arose, the proceeds being divided equally, while all female animals were retained until the end of the lease period and then divided equally. In another instance of renting Angus cattle to farmers for a five-year period the plan involved an equal division of all cattle at the end of the lease period. The farmer who took care of the cattle purchased a half interest in the herd. The division of the increase varied from year to year. Of the first generation of calves three-fourths went to the farmer, and of the second generation seven-eighths. The reason for this variation in the fractional division was found in the high cost of feed, which was supplied by the farmer.

Colts.—Very commonly when work horses belonging to the tenant are allowed free pasture and are fed from undivided feed, the landlord pays stallion service fees and receives one-half of the colts.

Hogs.—On hog farms, as in Iowa and Oklahoma for example, the tenant may supply all the labor, tools, and horses, and one-half the hogs, the cost for feed being shared equally. Under these conditions the proceeds from the hogs are divided half and half. Occasionally a farmer rents sows with pig from a hog owner and cares for them until the pigs are weaned. The pigs are then divided equally and the hog owner receives a number of sows equal to that originally furnished. If the pigs are fattened the owner of the stock must furnish one-half the feed.

Sheep.—On Indiana farms when the tenant supplies the tools, horses, and labor, and pays all the expenses, and the landlord furnishes all the sheep, the lambs and wool are divided in equal shares. At the termination of the lease, usually made for a five-year period, the tenant must return to the landlord the number of sheep furnished by him at the start. In other instances the landlord furnishes one-half the sheep and receives as his share of the proceeds one-half the wool. In Maryland, on general farms rented for one-half share, the tenant may supply the tools and work stock and one-half the fertilizer, seed, and productive stock, receiving one-half the proceeds from sheep.

Angora goats.—In a few instances goat breeders have rented goats to farm owners for one-half the mohair and kids. In such cases the farmer bears all expenses.

Poultry and eggs.—On most rented farms the tenant owns all the poultry, being allowed to keep 50 to 100 hens and occasionally a few ducks, geese, turkeys, and guinea fowl. Quite often, however, the tenant is prohibited from keeping any poultry except hens. In such cases the returns from the poultry belong entirely to the tenant, but occasionally the landlord may specify for himself the privilege of receiving eggs and fowls for table use. Where poultry constitutes

a more important enterprise in the operation of the farm the fowls may be owned jointly. In such cases as, for instance, in Delaware, on one-half share rented farms, the landlord receives one-half the eggs and increase. In a few instances on dairy farms, particularly in Indiana, the landowner receives two-thirds the eggs.

METHODS OF SHARING PASTURE.

In the corn belt the common practice on high-priced land is to require the tenant to pay a cash rent for pasture on crop farms, while in regions where land prices are low the tenant may receive the use of the pasture free as a perquisite. The cash rent for farm pasture ranges from \$1 to \$10 per acre, being usually \$4 to \$6 per acre. Such pasture land is commonly in a system of rotation, and it is considered as potentially crop land. The rent per acre, therefore, is fixed at about the same price as would be charged under a cash system for the crop area of the farm.

On general farms in Colorado, rented on shares with expenses shared equally, the tenant may receive one-half the proceeds from the use of pasture. These proceeds commonly come from fees for pasturing outside horses or other stock. In general, when the tenant has the free use of pasture for his work stock and a few cows and hogs, he is required to share equally with the landowner the colt and calf proceeds.

CONTRACTS FOR CLEARING LAND.

In some leases special stipulations are made regarding compensation of the tenant for clearing land. On an Indiana farm under a six-year lease the landlord furnished tile, while the tenant cleared the brush, fitted the land for cultivation and put in the tile drains, receiving as compensation all products produced on the land for the six-year period. Sometimes the tenant clears a few acres of land adjoining the other cultivated fields, receiving wages and all the crops for one year in return for his labor.

OWNERSHIP OF EQUIPMENT.

Share croppers on cotton farms usually provide none of the equipment, the tools, mules, and feed being furnished by the landlord, and other expenses except labor being shared equally, and receive one-half the cotton. Share renters on cotton farms usually furnish tools, mules, and feed, and receive two-thirds or three-fourths of the cotton. The landlord furnishes all equipment and horse labor on celery farms, as in the arrangement in vogue under the share-cropping

system for tenants, and receives two-thirds of the celery. The tenant under this system supplies all hand labor.

On general farms throughout the country where several extensive crops are produced, the tenant is commonly expected to provide tools and work stock. Occasionally the landlord may furnish certain pieces of machinery and sometimes a part of the horses; or rarely the landlord supplies all equipment as an offset to certain other considerations. On such farms the landlord's share is one-half, one-third, two-fifths, or some other fraction of all crops, according to local conditions. On some tenant farms in Ohio the landlord supplies all equipment and receives two-thirds of all crops. On a few Virginia farms where the tenant furnishes all equipment he receives three-fourths of the crops; usually, however, in that State under these conditions the tenant's share is two-thirds.

On stock farms it is customary for the landlord and tenant to hold an equal interest in all productive stock. They either purchase the stock in partnership or one owns the stock before the contract is entered into and the other buys a half interest, or the landlord may provide all the stock, sharing the increase and proceeds equally. In such cases the landlord receives at the expiration of the lease his original number of stock. Occasionally the landlord may own all productive stock, pay the tenant wages for caring for the stock, and take all stock proceeds. The tenant thereby obviously becomes a mere hired laborer. In a few instances the landowner supplies all of the poultry and receives as his share one-half the eggs and increase.

On dairy farms custom varies with regard to the ownership of the cows, pigs, and poultry. In Wisconsin the cows and chickens are commonly owned half and half. Sometimes the landlord owns all the cows and chickens. More frequently the tenant owns all of the chickens. In Illinois the landlord usually owns all cows, the tenant bearing one-half of the cost of cows to replace those that die, while less often the cows are owned in partnership. The tenant most frequently supplies all of the chickens, but they may be owned jointly. In Vermont the landlord usually owns all of the cows and the tenant one-half of the other productive stock. In Delaware the landlord usually owns all of the cows or, less frequently, one-half of them. In New Jersey the tenant commonly owns one-half of the cows and hogs and all of the poultry, receiving all of the returns from the poultry, while other proceeds are divided equally. Occasionally, in Sussex County, N. J., and in Delaware, the tenant may furnish only the labor, while the landlord owns all the cows and pays two-thirds of the cost of feed and fertilizer, receiving as his share two-thirds of the dairy products. In Pennsylvania the landlord commonly owns

one-half of the cows and other productive stock. A similar custom prevails in Maryland, Michigan, Indiana, Iowa, Minnesota, and Washington.

METHODS OF SHARING EXPENSES.

A wide variation is seen in different localities in the methods of sharing operating expenses. Frequently individual items of expense are not strictly shared, but are assigned, some to the landlord and some to the tenant, in an attempt to equalize the burden of expense. An increasing tendency, however, is seen toward specifying in the lease the fractions of different items of expense to be borne by the landlord and tenant. Recently the custom seems to be gaining ground of sharing all expenses equally.

FERTILIZERS.

Share croppers on cotton farms usually provide one-half of the fertilizer, or in some cases the landlord supplies all fertilizer. Share renters, on the other hand, furnish three-fourths or two-thirds of the fertilizer, according as their share of the cotton is three-fourths or two-thirds. On half-share dairy farms and general farms in Delaware the landlord provides one-half of all of the fertilizer. The landlord almost invariably supplies all lime used on the farm. In Indiana and Illinois the landlord commonly provides one-half of the fertilizer, less often all of it. Similar conditions prevail generally throughout the country. The sharing of the cost of fertilizer is often proportionate to the share of crops. On the other hand, the landlord often provides the larger share of the fertilizer, for example, two-thirds, three-fifths or three-fourths on half-share rented farms. In many instances the landlord provides all of the fertilizer, especially in case of an annual lease. On tenant truck farms in New Jersey, for example, the landlord furnishes all manure and usually all of the commercial fertilizer.

SEED.

The farm owner commonly pays for one-half of the seed or plants in the case of grain, potatoes, corn, cabbage, cucumbers, and various other crops, but all possible methods for dividing the expense of seed are in vogue. For example, the landlord frequently supplies all grass and clover seed and one-half the other seed, or he may furnish all seed, or in some cases the tenant may supply all seed, or finally, the landlord may supply all grass seed while the tenant furnishes other seed, especially in case of an annual lease where the tenant can not expect to derive the full benefit from the use of grass seed.

CRATES, HAMPERS, BASKETS, BARRELS, BOXES, BAGS, ETC.

Expenses for all of these articles are usually borne equally. Bags for grain may be supplied in proportion to the share of the crop received by each party. The tenant may provide one-half or all of the baskets for tomatoes. Bags for onions may be equally shared, but in some cases the purchaser pays for them. On other farms the landlord may provide all crates for onions and all barrels for apples, or may furnish a part of them in proportion to his share of the crop.

GINNING, THRASHING, TWINE, FUEL, AND OIL.

The share cropper on cotton farms usually pays one-half the expense of ginning, and share renters pay their proportionate share of ginning (two-thirds or three-fourths), while the landlord usually provides the fuel. On grain, dairy, stock, and general farms throughout the country the cost of thrashing, twine, fuel, and oil is either shared equally or the landlord provides all or the tenant all. In still other cases the thrashing expense is shared equally while the tenant pays for the twine. Or, finally, the thrashing expense may be shared in proportion to the tenant's and landlord's shares of grain.

SILO FILLING, SHREDDING, AND BALING.

Expenses for these operations are commonly shared equally. In some cases, however, the tenant pays for all of them, while very frequently the baling expense is shared in proportion to the shares of the hay.

MILK CANS, MILK HAULING, AND MARKETING CROPS.

On dairy farms the tenant provides all or the larger share, or one-half of the milk cans, according to local custom. In Illinois the tenant furnishes one-half or more of the cans, while in Wisconsin he provides all of the cans. The tenant nearly always bears the expenses of hauling milk. Leases nearly always contain a clause on the method of sale and marketing of partnership crops and on the delivery of the landlord's share of the crops. A division of crops may be made at the farm, after which the landlord's share of the crops may be stored in a crib, granary, or barn. In other cases the tenant may be required to deliver the landlord's share to his home, elevator, railroad station, or to any point within a specified distance at the discretion of the landlord. On Kansas grain farms the landlord may receive one-third of the grain at the farm or only one-fourth if delivered by the tenant to the railroad station 10 miles distant. Again in Indiana the landlord may receive one-half of the potatoes in the field or one-third "in the bushel" at the tenant's

option. The tenant is often required to market all crop and stock products without previous division and to make the proper division of proceeds at a specified bank. In one instance on an Indiana peach farm the marketing expenses are shared equally. In the central wheat belt the tenant may be paid wages for delivering the landlord's grain to market, or may receive the free use of corn land in return for such labor.

SPRAYING, BLACKSMITHING AND VETERINARY FEES.

On stock and dairy farms ordinary veterinary fees and the cost of testing cows for tuberculosis and of vaccinating hogs for cholera are usually shared equally. Blacksmithing expenses are commonly borne by the tenant, or may be shared equally. Vitriol and formalin used for treating seed grain for smut may be provided by the tenant or may be shared equally. Spray material for use in orchards and on other crops is commonly provided jointly, or may rarely all be furnished by the tenant or the landlord. The tenant usually supplies labor for spraying. On celery farms in California the landlord supplies all spraying material.

FEED.

On stock and dairy farms in Wisconsin, Iowa, Illinois, Pennsylvania, Delaware, Virginia, and elsewhere, the cost of purchased feed is usually shared equally. The tenant's work stock may or may not be fed from the common grain and fodder. When stock breeders rent stock to farmers on shares the farmers are usually required to furnish all necessary feed.

LABOR.

The tenant usually supplies all labor, not only his own but also hired labor and horse labor. At the opposite extreme, however, there are instances in which the tenant receives wages for his own work, while all horse and hired labor is shared equally. On celery farms in California, on cotton farms leased to share croppers, on onion farms in Massachusetts and New York, and occasionally on general farms in various States, the landlord supplies all horse labor and the tenant all hand labor. On a peach farm in Indiana the cost of hired labor is borne jointly. The cost of hired labor on dairy farms is often shared half and half, as it is also on a sunflower farm in Kentucky. Landlord and tenant often share equally also the labor of picking berries in Louisiana, Maryland, and elsewhere, and occasionally on general farms in Michigan, New York, South Dakota, and elsewhere—usually also the labor of picking hops, and occasionally the cost of plowing, especially on North Dakota wheat farms. Some-

times the landlord pays wages for the family labor of the tenant. In Ohio the extra labor required in handling tobacco is commonly shared in proportion to the shares of the crop. On share truck farms the landlord usually pays a part of the cost of labor required in picking and harvesting the crops.

MISCELLANEOUS EXPENSES.

Storage and freight.—Cold storage expenses on apples and other fruits and freight on stock shipments and on other products are usually shared equally or in proportion to the tenant's and landlord's share of the products.

Service fees.—The landlord in most cases pays all stallion service fees, and under such conditions may receive one-half the colts produced by the tenant's work horses.

Water assessments.—On irrigated farms in Colorado and elsewhere, the landlord may pay all water rates, or less often this expense may be shared equally, or in some cases the tenant pays all. In all cases, however, the tenant is required to keep irrigation ditches, weirs, and flumes in order.

Taxes, insurance, and telephone.—The landlord usually pays all insurance on real estate, while the insurance on partnership live stock and equipment is shared equally. Occasionally the tenant pays the insurance on real estate, especially in the case of an absentee landlord. The tenant may pay the road taxes and school taxes, while the landlord pays other real estate taxes, or the tenant may pay one-half of the road taxes. In some cases the landlord pays all real estate taxes, while in other instances all taxes are shared equally. Taxes on partnership stock and equipment are almost always shared jointly or in proportion to the shares of the proceeds. In North Dakota the tenant may work out the road tax in return for the free use of corn land, especially on wheat farms. The tenant usually pays the rental for telephone services, though sometimes this expense is shared.

UNEXHAUSTED VALUE OF FERTILIZERS.

Little attention has been given in this country to the practice, universal in the English tenant system, of granting an allowance to a departing tenant for the unexhausted value of fertilizers bought and applied by him during his period of tenancy. This principle is recognized with respect to lime, which is nearly always paid for by the landowner. But there are other materials, commonly applied to the soil, which are not exhausted in a single year. Rock phosphate, for example, is not exhausted within a period shorter than four

years. If, therefore, a tenant applies rock phosphate one, two or three years before the termination of his period of tenancy, he does not receive the full benefit of the expense which he has incurred. The matter is frequently discussed in agricultural papers, but rarely, if ever, is it taken into consideration in leases. If a tenant by his own efforts and progressive methods increases the productivity of a farm, it is only just that the improvement should be duly recognized.

REPAIRS AND IMPROVEMENTS.

The landlord almost universally furnishes all materials needed in repairing buildings and fences, and in making other permanent improvements as required, while the tenant furnishes all labor except skilled labor necessary for making the required repairs and improvements. The tenant, however, is commonly paid wages for work on extensive improvements, such as ditching, tile draining, building silos, etc. Often the landlord pays for the services of a skilled horticulturist to prune orchards or instruct the tenant how to prune them. In the case of extensive improvements the landlord may supply all labor while the tenant is required to board the laborers.

PRIVILEGES AND PERQUISITES.

The landowner may grant certain privileges to the tenant free or for a fixed sum of money or other valuable consideration, and may also reserve certain rights for himself. The tenant's perquisites commonly include the use of dwelling house, other buildings, garden, and pasture, the taking of dead and down timber for fuel, the keeping of 50 or 100 chickens, and more rarely a few guinea fowls, ducks, geese, and turkeys, the raising of a few hogs and cows to supply his family needs, and the use of fruit and other farm produce for his table. Frequently the landlord grants the tenant the privilege of keeping a considerable number of cattle, hogs, and poultry, the tenant receiving all proceeds from such stock in return for the manure which they produce.

All these privileges may be granted free, or the tenant may be required to pay a lump sum for the use of the farmstead, or a fixed sum per acre. In some cases of partnership farming the value of all products taken for table use by the landlord and the tenant is charged against their respective accounts.

The landlord may reserve the use of one or two rooms in the farmhouse, or a portion of the garden, or certain timber areas or hunting rights. Moreover, the landlord may reserve the privilege of the joint use of the farmhouse, living expenses being shared proportionately with the tenant, or the right to receive poultry, eggs,

pork, milk, fruit, potatoes, and other farm products for table use, or the right to keep a driving horse in the pasture. Sometimes the tenant is required to pay a special "improvement rent" of \$25 annually in return for improvements to be made on the place by the landlord.

RESTRICTIONS.

The lease contract often contains a clause placing certain restrictions upon the operations of the tenant. For example, it is sometimes specified that alfalfa and clover land shall not be over-grazed, that stock must not be turned upon the pasture in the spring until the frost is out of the ground, that hogs must be ringed to prevent rooting, or must be immunized against cholera before being brought on the farm, or that the tenant must cut no young or growing timber. Some landowners do not allow the tenant to keep sheep, goats, pigeons, geese, ducks, or turkeys. Frequently the lease prescribes that no straw shall be burned, that cornstalks must be plowed under, that a certain rotation must be followed, that no fodder may be sold from the farm, that certain specified crops shall not be grown, that certain pasture land shall not be plowed, that a specified area shall be kept in pasture and meadow, or that only a specified number of horses shall be kept by the tenant.

SUPERVISION BY THE LANDLORD.

The amount of supervision exercised by the landlord ranges from daily or weekly visits to the farm, involving constant consultation with the tenant concerning all farm operations, or rare or occasional visits, to a condition of complete aloofness in which the landlord's only apparent interest is in receiving the rent. The landlord may live on a neighboring farm or in a near-by town or in another county or city or even in a foreign country. Naturally the landlord's interest in the farm operations is less under a cash-renting system than under a system of share farming. In partnership farming, in which each party furnishes part of the equipment and both expenses and proceeds are shared, it is commonly stipulated that all important matters shall be settled by consultation between the landlord and tenant.

GOOD HUSBANDRY.

Lease contracts commonly stipulate that the tenant shall operate the farm in a "good husbandman-like manner" or in a "workman-like manner." These phrases are accepted as meaning that the tenant shall plow to a proper depth, do all farm operations at the proper time, promote crop yields and prevent waste, keep drains open, destroy weeds, haul out manure, etc.

ADVANCES TO TENANT.

Advances of cash or supplies by the landlord to the tenant usually bear the current local rate of interest and are ordinarily secured by crop lien, chattel mortgage, or both.

GENERAL SYSTEMS OF SHARE LEASING.

DAIRY FARMS.

On dairy farms the landlord may provide one-half of the cows, while the tenant furnishes the other half of the cows and all of the horses and machinery and receives one-half of the proceeds. In other cases the landlord may own all the cows while the tenant furnishes all other equipment and receives one-half of the proceeds. In such cases the tenant bears one-half of the loss by death of the cows or one-half of the cost of cows purchased to keep up the herd. In still other instances the landlord may furnish everything except labor and receive two-thirds of the proceeds. In the first two systems expenses are shared about equally, while in the third system expenses are borne in proportion to the shares of the landlord and tenant in the proceeds. Occasionally all equipment, including cows, hogs, poultry, work horses, tools, machinery, and other working capital, are shared equally, as well as all expenses of whatever nature. In this case also the proceeds are shared half-and-half.

STOCK FARMS.

On stock farms the tenant commonly supplies tools and horses while the landlord furnishes half of the productive stock and receives one-half the proceeds. The landlord may provide all of the productive stock, or other modifications of this system may be adopted, though usually any such adjustment is to make fair a half-and-half sharing of the proceeds.

GENERAL FARMS.

In general farming, as well as in grain farming, the tenant may furnish the tools and horses and pay the landlord as rent one-half, two-fifths, one-third, two-sevenths, or one-fourth of the crops, according to the local conditions. In other instances the landlord may furnish all of the equipment and take two-thirds of the crops or more; rarely only one-half of the crops. On cotton farms where the tenant furnishes all equipment he receives two-thirds or three-fourths of the cotton and where he supplies only the labor he receives one-half of the cotton.

These few cases may be taken to illustrate the types of share leasing systems in which the landlord receives a certain fractional part

of all crops and products of a given farm rather than different fractions for different crops. A study of actual leases shows that, aside from large estates where a uniform contract is prescribed for all tenants on a given estate, there are rarely two lease contracts containing identical stipulations.

Leases vary in their main features and in almost innumerable less important details. They differ in the method of sharing equipment, expense, and proceeds. They show how greatly varied have been the attempts to balance one item of expense or equipment with another. They may specify a long list of items of expense, equipment, privileges, perquisites, restrictions, reservations, etc., which are not shared but are to be borne or enjoyed exclusively either by the landlord or by the tenant. The money value of these expenses and privileges can not be known in advance, but only at the end of the year. These items may amount in the aggregate, however, to an important sum for both parties.

In some cases no items of expense or privileges are shared. In such leases the items are merely divided between landlord and tenant in a manner which is supposed to be more or less fair. The landlord may pay for the fertilizer, lime, grass seed, twine, etc., while the tenant pays for thrashing, grain seed, blue vitriol, and fuel. Both the tenant and landlord may enjoy a large number of privileges of which the money value is not determined nor even approximately estimated.

SAMPLE STOCK-SHARE LEASE.

Farm leases examined during this study vary in length from 1 to 14 typewritten pages, according to the amount of detail which the contracting parties wish to specify. The following is a sample stock-share lease form for use on farms on which live stock is owned in common, as adopted by the landlord-tenant conference under the auspices of the Winnebago County Farm Improvement Association, held at Rockford, Ill., January 31, 1916. It does not contain a clause stating how the lease may be renewed, but otherwise is sufficiently detailed.

This indenture, made and entered into this — day of February, 191—, by and between ———, party of the first part, lessor, and ———, party of the second part, lessee,

Witnesseth, that the first party in consideration of the agreements and stipulations hereinafter mentioned to be kept and performed by the second party, has leased and does by these presents rent and lease unto the second party, the following described real estate situated in the county of ——— and the State of ———, to wit:

(Example: NE. — sec. —, T. —, R. —, containing — acres.)

To have and to hold the said premises unto said second party from the 1st day of March, 191—, at 12 m., to the 1st day of March, 191—, at 12 m., being

a term of one year, with the privilege of renewal for each succeeding year as long as both parties agree.

This leasing arrangement is known as a stock-share plan. The parties to this contract shall be partners¹ and will cooperate fully according to the terms of this lease, in order that each may receive the largest returns consistent with a practical system of cropping and soil management which shall maintain and even increase the fertility of the land, with the purpose that this farm shall not decrease in productiveness and value.

The type of farming, as agreed upon, is live stock and ——. The plan is to feed most of the crops on the farm, depending upon the sale of live stock and dairy products as the principal source of income.

(Here state as fully as desired the kind and number of live stock to be kept on the farm; also the plans for crop rotation and soil fertilization.)

The following shall be furnished and shared by ————:

The first party will furnish above-described farm, including the improvements thereon, and shall pay all taxes and insurance on said property. He shall furnish material needed for repairs and improvements, and shall build new permanent fences and make other permanent improvements as required, and shall furnish all phosphates and limestone fertilizers required on said farm. He shall pay stallion-service fees on mares owned by lessee; colts to be owned in common.

The second party shall furnish all horses (not to exceed ———), harness, implements, farm machinery, and labor necessary to do all work required to properly conduct this farming business as described in this agreement. He shall make all repairs and improvements where skilled labor is not required, except as herein specified. He shall haul, from railroad station or ——— source of supply, all material for repairing buildings and fences, which may be needed in the operation of said farm. He shall haul from ——— railroad station or ——— source of supply and spread on the land limestone, phosphate, and other fertilizers purchased by lessor for use on said farm. He shall deliver to ——— market all produce from the farm free of cost to lessor. Lessee agrees to operate said farm in a workmanlike manner, and to do the necessary work in good season and to care for the crops and live stock properly, preventing all unnecessary waste or loss or damage to lessor's property. He further agrees that he will not burn any cornstalks, straw, or other vegetable matter grown upon said farm, but that all this material shall be spread upon the land as manure.

Lessee may have potatoes and garden truck and such fruit as the farm affords, milk, poultry, and eggs, for family use only.

Lessor and lessee shall furnish jointly all seed grain, grass seed, clover, and alfalfa seed sown on said farm during the period of this lease; also all live stock other than work horses, and feed, including hired pasture, if such becomes necessary, for the same, including lessee's horses. They shall furnish binder twine and all fuel for tank heater, thrashing, corn shredding, silage cutting, hay baling, corn shelling, clover hulling, veterinary fees, and stallion service fees on mares owned in common. Each party shall pay one-half of all taxes and insurance on all personal property owned in common.

They shall share equally in all the proceeds from the sale of live stock, poultry, grain, and other produce raised on said farm. Milk and cream checks shall be divided by purchaser. The butter used by either party shall be taken out of his share. Each party may gather and keep his own share of fruit. Buying and selling of materials, live stock, and other farm produce shall be left largely with the lessee, but all sales and purchases of more than \$———

¹ This agreement is not a legal partnership.

shall be made with the knowledge and consent of the lessor. All joint business in the way of payments and receipts shall be through ——— Bank of ———.

Both lessor and lessee shall own in common, each an undivided one-half, all live stock, excepting as hereinbefore provided for, owned and produced upon said farm; and such of said stock as the parties shall agree upon shall be sold at such time as may be satisfactory to both.

Whenever any cattle, hogs, grain, corn, or hay or any other product of said farm shall be sold, the proceeds shall be equally divided between the parties, or, if agreed upon, it may again be invested in other stock, grain, or material for the common use and benefit of the parties.

Lessee further covenants and agrees that he will farm said land in a good, farmlike, and workmanlike manner; that he will commit no waste nor suffer injury to be done to the premises; that he will allow no noxious weeds to go to seed on said premises, and will keep the weeds and grass cut in the roads adjoining the land.

Lessee also agrees that he will draw out and scatter on said premises, on or before December 1st of each year, on the fields where it is most needed, following out the plan of farming agreed upon in this contract, all manure being and made on said premises up to December 1st next preceding the end of the term, and that in default of so drawing out and scattering said manure, he shall pay to lessor as penalty the sum of \$——.

That he will leave as many acres plowed on said premises at the end of his term as he finds plowed when he takes possession, and in default of so doing he shall pay to lessor \$—— an acre for each acre short of such number.

That he shall keep the buildings, fences, and other improvements on said premises in as good repair and condition as the same are when he goes into possession, or as good as they may be put in during said terms, loss by fire or inevitable and ordinary wear excepted; that he will not assign this lease or sublet any part of said premises without written consent of lessor; that he will not bring mortgaged property on said premises without the consent of said lessor; that he will not sell or remove any of the farm crop from said premises without the consent of the lessor; that he will not break up any established watercourses or ditches or undertake any other operation which will injure said land.

That in case he shall, from any cause, neglect, refuse, or be unable to properly prepare said land, sow, plant, harvest, or care for any and all crops to be raised on said land, said lessor, his agents, heirs, or assigns, may at their option take possession thereof and of the crops growing or being grown thereon, and properly care for the same, and sell the same, and the proceeds remaining after payment of the rents, cost, and expenses and damages shall go to lessee. That he will surrender the stubble land, for the purpose of plowing, in the fall preceding the termination of this lease, as soon as the crop has been removed from the same; that he will surrender possession of said premises at the end of the term, or sooner termination thereof, and if immediate possession be not given, that he will pay lessor, or assigns, the sum of \$—— for each and every day possession is thus withheld, as damages for nonsurrender.

That a failure to keep and perform any of the agreements hereinbefore mentioned shall, at the option of said lessor, or assigns, operate as a forfeiture of this lease and terminate the term, and lessor may take possession of the premises at once without process of law, or he may bring an action at law for possession, said lessee being, from the date of such failure, a tenant holding over after the expiration of his term; that in consideration of this lease, and the agreements herein contained on the part of the lessor, said lessee covenants and agrees to keep and perform the agreements hereinbefore set forth, hereby

covenanting that moneys due from him to said lessor for plowing, or damages, or otherwise, shall be and hereby are declared and made a perpetual lien on any and all crops, stock, and other personal property of lessee at any time kept, had, or used on said premises, whether the same are exempt from execution or not, such lien to attach from the commencement of the term.

Said lessor reserves the right of himself, his employees, or assigns to enter upon said premises at any time for the purpose of viewing the same or making repairs or improvements thereon, the same not to interfere with the occupancy of the lessee; and reserves the right to himself or agent to enter upon said premises for the purpose of plowing the stubble land, from which the crops shall have been removed, in the fall preceding the termination of this lease.

It is understood and agreed by both parties that the lessee's reward for all farm improvements which he is required to make according to the terms of this contract shall come in the increased yields and greater returns which should result and which will be shared by lessee if he continues to operate said farm.

But in case this lease is terminated before lessee receives the benefit from such improvements, he shall receive reasonable compensation for such improvements. For example, hauling and spreading rock phosphate and ground limestone, seed clover and alfalfa, laying drainage, tile, stump pulling, etc.

(Here state reward to be given lessee for unexhausted improvements.)

That in consideration of this lease and the agreements herein contained on the part of the lessee, said lessor covenants and agrees to keep and perform the agreements herein set forth, hereby covenanting that any compensations due from him to said lessee for improvement work, etc., shall be a lien on his share of the personal property, and must be paid before the proceeds are equally divided.

And likewise, for failure to provide for and carry out any improvements on said farm which are agreed to in this lease, said lessor shall be liable for damages to said lessee to reimburse him for the loss which may result from such default.

At the end of the term of this lease, an accounting shall be had between the respective parties hereto, and the produce, stock, etc., upon said farm belonging to lessor and lessee shall be equally divided. Lessee shall divide each kind of live stock into two equal lots, as near as may be, and lessor shall have his choice of lots of each kind of live stock, which division shall be final and binding upon both parties. And if a proper settlement can not be made in this way, all parties hereto agree to have a public sale on the premises for the purpose of dissolution. After all joint debts of lessor and lessee and the expenses of having the sale are paid, the proceeds shall be equally divided.

But if one or both parties object to a sale and prefer a division of said property, then each shall select an arbitrator. They jointly shall select a third, and the three shall make such division of said property as to them shall seem equitable, giving each party one-half of the same, after deducting from each party's share such indemnities or adding such compensations as may be justly charged or credited to him according to the terms of this contract.

Neither party shall have the right to bind the other by any contract outside the scope of this agreement, or by any purchases made within the scope of this agreement, except with the consent of the other, unless hereinbefore provided for.

(Signed) _____.

(Signed) _____.

ASSUMPTIONS UNDERLYING LEASE CONTRACTS.

A study of leases in actual operation discloses the existence of a few interesting general assumptions which are of much value in establishing a basis for a rational form of lease contract. Share renters on good cotton farms may pay the landlord one-third the cotton, but only one-fourth on poor farms. Similar arrangements are to be noted in other parts of the United States. The obvious assumption underlying this adjustment is that on fertile farms the landlord is entitled to a larger share of the crops than on poor farms under otherwise similar conditions. The same consideration is, of course, apparent in renting land for cash, the cash rent per acre varying with the agricultural value of the land.

In many cases the landlord accepts as rent a smaller share of the produce delivered at the railroad station than at the farm. For example, on a Kansas grain farm the landlord takes one-third of the wheat at the farm or one-fourth at the railroad station at the option of the tenant. The assumption in such cases evidently is that the farther the farm from market the smaller should be the landlord's share of the crops if the tenant is required to haul them to market. This assumption is manifestly in accord with justice and common sense.

On general farms the landlord's share is often different for different crops. For example in Colorado the landlord may get one-half of the hay, one-third of the grain, and one-fourth of the sugar beets, or one-half of the hay, one-half of the apples, one-third of the wheat, one-third of the potatoes, and one-fourth of the sugar beets. In Delaware the landlord may get two-fifths of the tomatoes and one-half of the grain, or one-fourth of the tomatoes and one-half of the grain. In Indiana the landlord may get two-thirds of the eggs and one-half of the milk, or one-half of the hay and corn and one-third of the wheat and oats, or two-fifths of the wheat and one-half of the corn. In Iowa the landlord may get one-half of the hay and two-fifths of the corn. In the cotton belt the landlord may get one-third of the corn and one-fourth of the cotton. In Michigan and Missouri the landlord may get one-half of the hay and one-third of the corn. In Nebraska the landlord may get one-half of the hay and one-fourth of the corn. In Ohio the landlord may get one-half of the hay and corn and three-sevenths of the tobacco, or one-half of the hay and corn and two-fifths of the tobacco and apples. In all these cases of variation in the shares of different crops on a given farm the tenant provided all labor. The specified differences in the shares of different crops is an acknowledgement of the fact that more labor is required for the production of certain crops than for others, and that the shares should in justice be correspondingly modi-

fied. More labor must be expended on sugar beets, potatoes, tobacco, and grain than on hay.

On relatively infertile farms the landlord may provide tools and work horses, pay one-half the expenses except labor and take one-half the products. The plain assumption here is that on these poor farms the land is not equal to the labor in productive value but that land and equipment together approximately equal the labor.

There are a few instances of partnership farming of which an Indiana farm may be taken as an example. On this farm the landlord furnishes one-half of all equipment, including tools, machinery, cows, other productive stock, and work horses. All expenses, including even taxes and hired labor, are shared equally, and the proceeds are divided half and half. In this case the underlying assumption evidently is that the tenant's head and hand work is equal in value to the use of the land, for everything except land and the tenant's own labor is shared equally.

Many lease contracts used in farming by the general half-share system stipulate that the tenant shall furnish all tools, machinery, and work stock, and one-half of the cows and other productive stock, and that expenses shall be shared equally. Here the assumption is that the tenant's labor is not equal in value to the use of the land, but that the tenant's labor plus the use of tools and horses equals the use of the land.

Thus it appears to be assumed in lease contracts that on average farms labor offsets or balances the use of the land, while on poor farms labor is of more value and on exceptionally fertile farms of less value than the use of the land. This is merely another way of saying that the landlord's share of the crops should vary with the agricultural value of the soil.

It may be well to discuss further some of the points involved in these assumptions, especially since there is at present an active interest among landowners and tenants in attempts to arrive at a rational basis for lease contracts.

The assumption that labor offsets or balances the land underlies much of the discussion of tenancy in England and also prevails widely in this country. This assumption seems to involve, as a more precise definition of the amount of labor concerned, an amount sufficient to carry on the ordinary operations of a farm under a system of general farming.

If, therefore, we start with the assumption that the amount of labor necessary to operate a farm for general purposes is equal in value to the productive power of the farm, it would then seem fair to assume that for the equal sharing of all farm produce between tenant and landowner, each should contribute one-half of the

necessary investment in work stock, productive stock, implements, farm machinery, and other operating capital, and should also share equally all expenses connected with the operation of the farm. In several individual instances this plan has been used as a basis of a half-and-half share lease and has apparently given good satisfaction to both tenant and landowner. Under such a contract the extra labor involved in the production of special or intensive crops should naturally be considered as a part of the expense. This would apply to such crops as berries, tobacco, hops, cotton, onions, sugar beets, celery, and also to potatoes and apples.

It is obviously desirable that farm leases should be based on a plan which will not only give the tenant an elastic value for his labor and managerial ability to compensate for the possible rise of land values under the influence of speculative expectation and of competition of tenants, but will also give the tenant an equal personal interest with the landowner in the use of the most businesslike and scientific methods of farming to increase production, and also in economy with reference to all expenses connected with farm operations. These desirable features of a satisfactory form of lease would seem to be largely supplied by the contract in question. In one of the few individual instances in which essentially this form of contract is now in operation it is provided in the contract not only that all working capital shall be furnished in equal shares and that all expenses shall be shared equally, but also that all farm products used for family purposes by either the tenant or landowner shall be paid for by the respective party to the agreement. In cases where it is not convenient for landowner and tenant to furnish exactly equal shares of the working capital, all requirements of justice and fairness would be served by allowing each party the interest on his share of the working capital, to be taken out of the gross proceeds before the final division into equal shares. Where the landowner and tenant do not contribute equal shares of the working capital, it would be necessary to take out not only the interest on the unlike shares, but also all expense of the farm operations, before dividing the net proceeds into equal parts. If, however, the sharing of the working capital were equal, the amount of farm income to be shared equally could readily be determined by subtracting the total expense from the gross returns.

The great variation which is to be noted in the shares of the landowner and tenant in different systems of share leasing is evidence of the long struggle which has been undergone in attempts to devise methods of division satisfactory to both parties. It is apparent, however, from the variation in the shares for landowner and tenant proposed in leases, that the method of division has come about as a

result of mutual demands and concessions and is therefore for the most part the final outcome of the blind operation of economic forces rather than the result of a deliberately planned system of division.

It would seem that the main physical factors which operate in the production of farm products are land, working capital, and labor. If, therefore, an agreement could be reached on a reasonable valuation of land and a reasonable rate of interest which this land should draw, and also upon a satisfactory payment for labor and a rate of interest on working capital, these three factors, namely, interest on land, interest on working capital, and wages for labor, could be used as a rational basis for a percentage distribution of products.

One of the great difficulties in establishing such a rational basis for the division of farm products under a share system of leasing is found in arriving at a proper estimate of the value of land. Farm land in the better farming sections is now held at prices which indicate the strong influence of speculative expectation of further rise in land prices. In fact much land is already capitalized at so high a price that the owner is forced to accept a lower rate of interest from the operation of the farm than could be reasonably expected from the same amount of capital otherwise invested. In estimating the value of the relative contributions of working capital and land to farm production, it is necessary to take into consideration the high relative risk and depreciation involved in the maintenance of live stock and farm machinery, as compared with the indestructibility of farm land. It may perhaps be fair to consider the relative contribution of a dollar invested as working capital as about three times that of a dollar invested in land, working capital yielding 10 per cent and land $3\frac{1}{2}$ per cent interest.

The tenant's services can not justly be considered as consisting merely of manual labor. His managerial ability is an important part of his services. It is unfair, therefore, to rate the tenant's services to the partnership at the same value for all values of farms in a given neighborhood. A labor income of \$500 might be an adequate recompense for a tenant's services on a \$10,000 farm, but on a farm worth \$50,000 his time and managerial ability are worth more. No business man would think of putting in charge of a \$50,000 plant a man whose services were worth no more than \$500. In order to obviate such an injustice to the tenant, it is necessary to assume that the value of his labor and managerial ability increases somewhat in proportion to the increase in the value of the farm.

The tendency at present is for the land to take an increasingly large proportion of the joint product of land, working capital, and labor. In many of the richest farming districts land values have become so high that the landlord's interest on his investment is only 3

or 4 per cent. If, for example, \$1,200 is the maximum rent which a landowner can expect to obtain for the use of his farm by a tenant, it is apparent that the owner may consider this \$1,200 as 2 per cent interest on \$60,000 or 4 per cent on \$30,000. Some landowners have felt that the rate of income derived from rented land ought to keep pace with the increase in land values. In the attempt to obtain such an increase of income they have tried to avoid the appearance of claiming more than one-half of the net proceeds. This has been accomplished by requiring the tenant to furnish more than half of the working capital, by charging cash rent for the farmstead, pasture, or certain other "privileges," or by exacting an arbitrary "improvement rent." The tenant is thereby forced to pay as rent not only half of the farm income but also an additional sum in cash.

There is an obvious advantage to both parties in the strictly half and half system of leasing. It offers no opportunity for either party to get the better of the bargain by indirect methods. Landlord and tenant contribute equally to the partnership, share all expenses equally, and therefore receive equal shares of the farm income. The manner in which this system operates may be seen in the following average example constructed from survey records on farms in the corn belt. In this example the business of a 160-acre farm worth \$25,000 is analyzed on a basis of good average yields and normal prices under a strict partnership system of leasing.

Analysis of the business of a \$25,000 farm leased under the half-and-half system.

Receipts:

Crops—

	Tenant.	Owner.	Farm.
65 acres corn—			
1,500 bushels sold.....	\$375	\$375	
800 bushels fed.			
35 acres wheat, 1,000 bushels sold.....	500	500	
15 acres oats—			
300 bushels sold.....	60	60	
300 bushels fed.			
20 acres hay—			
5 tons sold.....	25	25	
20 tons fed.			

—
135 acres crops.
20 acres rotation pasture.
5 acres waste.

Stock—

12 cows, cattle, milk, etc.....	350	350
6 horses or mules.....	=35	=35
Swine.....	250	250
Poultry and eggs.....	75	75

Total.....	1,600	1,600	\$3,200
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Expenses:	Tenant.	Owner.	Farm.
Hired labor and board-----	\$200	\$200	
Family labor-----	25	25	
Cash expense of operation and repair-----	300	300	
Depreciation of equipment, 14 per cent of \$500--	35	35	
Depreciation of buildings, 6 per cent of \$2,000--	60	60	
Interest on working capital, 6 per cent of \$2,500--	75	75	
Taxes on real estate and equipment-----	80	80	
Total -----	775	775	\$1, 550
Farm income-----			1, 650
Reward for tenant's management and labor-----			825
Reward for use of real estate-----			825
Interest on real estate (per cent)-----			3. 3

The tenant receives \$825, half of the net profit, as a reward of his labor and management, also an allowance for half of the value of the family labor, and board of hired labor furnished, and the interest on his half of the working capital. His working capital is maintained at the same value at which he turned it into the partnership or is replaced.

The landowner receives, in addition to his \$825, an allowance of the interest on his half of the working capital, as well as having all taxes paid on his real estate and an allowance for depreciation.

Interest on working capital in the above example is charged at 6 per cent. The rate would be about 10 per cent if it included depreciation charges.

SUGGESTIONS TOWARD A RATIONAL LEASE CONTRACT.

The conditions under which the various existing types of share farming have developed have led landowners to include in lease contracts such a bewildering variety of rights and privileges of unspecified money value that at first sight it would seem impossible to say whether the contract is just or not. The approximate value of all these items, however, is generally known. Shrewd judgment and local experience enable the landowner and tenant to estimate closely what the thrashing, twine, feed, seed, and fertilizer bills will be. Nevertheless, lease contracts in which various items of expense and privilege are empirically adjusted and assigned to tenant or landlord are never, except by mere accident, strictly fair, but are always slightly in favor of landlord or tenant. Any injustice of this sort may become a source of friction between landlord and tenant and may lead to more frequent moving on the part of the tenant.

In some cases the tenant is a son or other relative of the landlord, in which event other considerations than those of strict business principles may be reflected in the stipulations of the lease. Or the owner may be a speculator merely holding the land for sale at an advanced price, being willing to accept a low rent pending sale and expecting to take his profit from the rise in the price of land rather

than in rent. But sheer generosity and charity are no more frequently seen in farm lease contracts than in other business transactions. Such cases may be left out of consideration, for most lease contracts are intended to be strict business propositions.

Many farm leases now in operation indicate an apparently satisfactory manner of eliminating all unknown quantities from a lease, reducing it to a simple, specific, and readily understandable form. According to these contracts all equipment, including tools, machinery, work stock, productive stock, and other working capital, is owned in equal partnership; all expenses, including hired labor and taxes, are shared equally, and the proceeds are divided half-and-half. All products taken for family use by either landlord or tenant are charged against the respective parties. This system is obviously fair and explicit. The objection may be raised that it involves much bookkeeping, but farm bookkeeping is desirable from every standpoint. In fact, many lease contracts stipulate that the tenant shall keep a complete daybook in which every item of expense and receipt is entered.

Such a contract provides a basis for the fair and equal sharing of all crops which may be grown on a farm, however unlike the amounts of labor required for their production, for if all expense for extra and hired labor is shared equally it is obviously just that the proceeds from crops requiring extra labor should be shared on the same basis as those which require little labor. Moreover, the unfairness of requiring the tenant to deliver crops to distant markets is obviated by sharing the expense of the labor thus involved.

Again, this plan is readily adaptable to cases in which the tenant and landlord furnish working capital in unequal shares. In such cases it is merely necessary to take out of the undivided farm income the interest on each one's share of the working capital and also the operating expenses, after which the remainder is divided half-and-half. Many leases constructed on this plan are in operation.

Share farming seems to be based on the idea of equal division of the proceeds. In those cases in which the fractions are not half and half, but one-third and two-thirds, one-fourth and three-fourths, or two-fifths and three-fifths the unequal sharing is an adjustment to the fact that operating expenses and the cost of equipment are not borne equally. Even in such cases it would appear preferable that all expenses and interest on the unequal shares of working capital be taken out of the undivided farm income and that the remaining proceeds be then divided equally. The feeling of full and frank partnership between the landlord and tenant would thus be kept to the fore. The tendency would thereby be to avoid reducing the tenant to the status of a hired laborer receiving a bonus in the crops as an inducement for extra effort.

While the central point upon which the various stipulations in farm leases for share renting are focused is the idea of providing a just basis for a partnership in which the proceeds shall be shared equally, the first attempts to provide such a basis were naturally only approximations to justice. The various items of expense and equipment were borne by the landowner or tenant in such a manner as to balance one another as nearly equally as might be. In cases where it was not convenient for landowner and tenant to share these items equally an adjustment was reached by dividing the proceeds unequally. Even in such cases, however, the idea of equal sharing was apparently the point of departure, and the unequal sharing of proceeds was an adjustment to the fact that the two parties had contributed unequally to the business.

At least two apparent exceptions to the fundamental half-and-half principle of tenant farming are widely prevalent. One of these is the share-cropping method of operating cotton farms. The area operated by a share cropper is usually too small to yield a living for his family and pay a reasonable interest on one-half of the working capital required for the operation of the farm. The share cropper is therefore required to furnish no working capital. In fact, he is virtually a hired laborer rather than a tenant.

The other exception is typified by a form of lease contract used in renting general crop farms throughout the country. Where there is actual competition among tenants for the opportunity to operate farms, landowners commonly exact a bonus in the form of a requirement that the tenant furnish most or all of the working capital. The assumption underlying this practice is, as explained above, that the tenant's own labor alone is not equal in value to the use of the land, but that labor plus working capital equals land in productive value.

Many recent farm leases indicate the possibility of using more flexible and, at the same time, more precise methods of adjusting the division of proceeds to the relative contribution of landowner and tenant to the partnership. These recent methods, which are gradually coming into vogue, involve in all cases the equal sharing of proceeds. Both landowner and tenant receive one-half of the net farm income. If equipment and other working capital are furnished in equal shares and all expenses are shared equally, one-half of the farm income naturally goes to each party without further adjustment. If the working capital is furnished in unequal shares, expenses and interest on each one's share of the working capital are taken from the gross returns, after which the net farm income is shared equally.

Underlying the lease contract in such cases is the assumption that the tenant's labor is equal in value to the use of the land. For

farms on which it is assumed that the tenant's labor is either of greater or less value than the use of the land, a modification of the same general method is coming into use. According to this modified plan it is stipulated in the lease that from the gross returns shall be taken a specified wage for the tenant, a specified interest on land for the landowner, and all expenses, after which the proceeds are divided equally. Under this system it has been found necessary to stipulate that the tenant's wages shall be paid before the interest on land is taken from the gross receipts. Otherwise, in poor years, the tenant might suffer an undue hardship.

In localities where land values, under speculative influences, have reached a figure higher than their actual productive power for agricultural purposes would warrant, it may in time become necessary to distinguish between the two elements in land values—actual productive power and the increase due to anticipated rise in price. In such an event it would seem fair to disregard the latter in leasing land for agricultural purposes, for the tenant shares only in the crop-producing power of the land, and can not participate in the speculative rise of land values.

STATUS OF THE TENANT.

The economic position of the tenant varies greatly under different systems of leasing. Under cash rent the tenant is completely independent. He makes plans on his own initiative, organizes his resources, determines all matters of policy at his own discretion, decides the time and manner of applying labor to the various farm enterprises, and receives all returns. Share leasing involves a partnership arrangement in which the two parties are jointly interested and determine all details of plan by mutual consultation. In some leases, however, it is stipulated that in case of failure of the landowner and tenant to agree on methods the judgment of the landowner shall prevail. If the landowner furnishes most or all of the equipment he retains title to all crops and products till they are sold and division made, and in general directs all farm operations. Under these conditions the tenant is virtually a hired man. Such tenants may receive money advances from the landowner and thus become even more dependent than the ordinary hired man. In fact there is no sharp line of demarcation in status between tenant and manager or hired man working wholly under direction of the landowner.

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